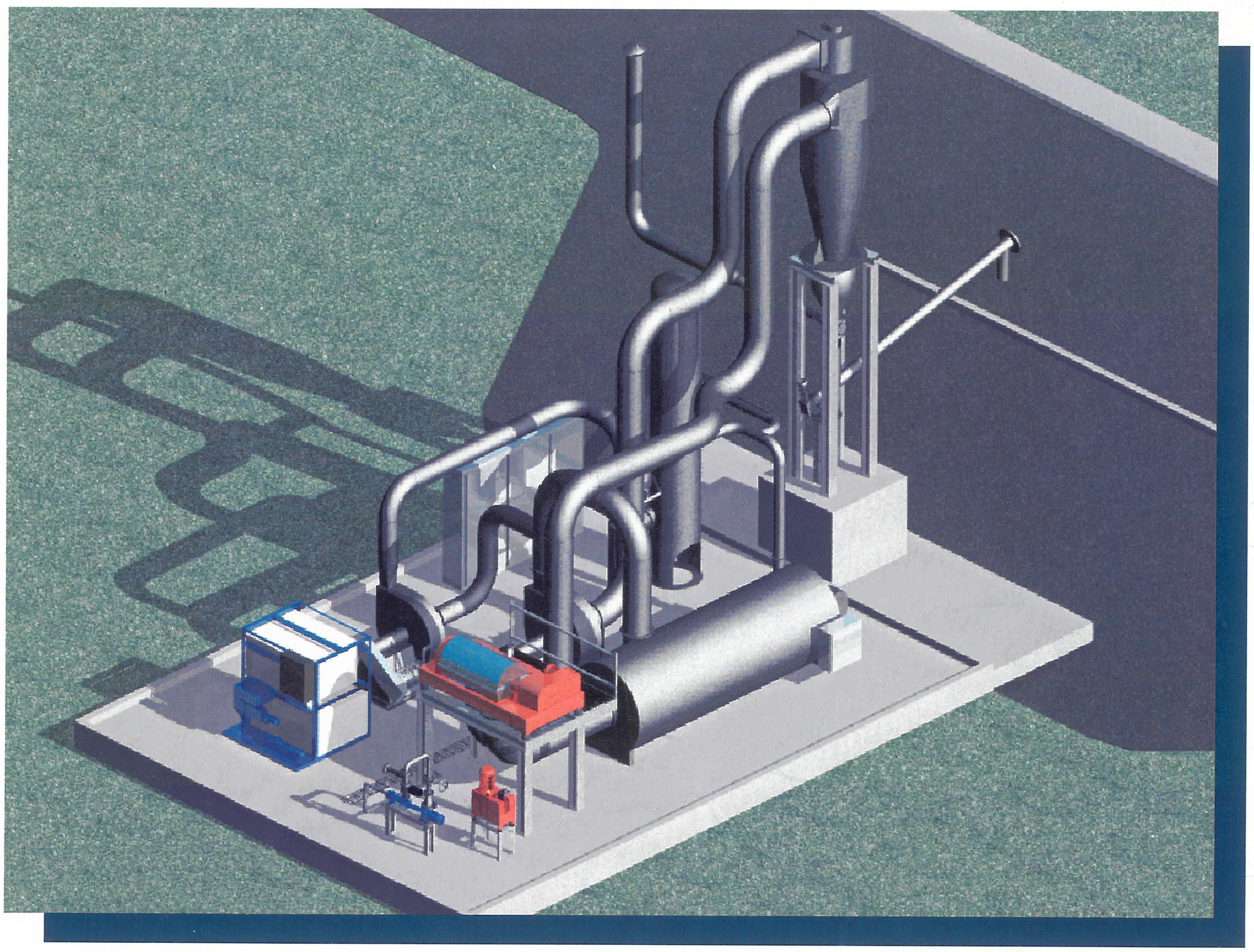
King County

Final Report:
Centridry Demonstration and Product Evaluation Project



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April 2002

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In association with:
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14-18398.004/1

Subject: Centridry™ Product Evaluation Project
Final Report

Dear Mr. Smyth:

Enclosed is the Final Report for the Centridry™ Product Evaluation Project. This report documents the efforts of King County, Brown and Caldwell, and our subconsultants (in particular E&A Environmental Consultants--now Tetra Tech), over the last seven years in the evaluation of the Centridry™ technology and its potential application to King County.

We believe that this project represents one of the most thorough biosolids processing technology evaluations undertaken in our industry. Each of the following aspects of this process has been considered in significant detail:

- Mechanical reliability;
- Process reliability and operability;
- Odor and air emissions;
- Cost to implement, operate, and maintain over time;
- Product quality and its viability in the Northwest biosolids marketplace, including composting to Class A quality.

The results of the project indicate that there is no economic advantage to King County to implement Centridry™ in the foreseeable future. Nonetheless, we believe that the production of a diversified biosolids product (that is, biosolids that are drier and more soil-like in texture compared to the dewatered cake produced at each of the County's regional treatment plants), may offer advantages to King County. Specifically, a diversified product may allow King County to expand its market to more users, which could in turn yield significant savings in biosolids haul and application costs. If biosolids market conditions change, we believe that Centridry™ should be reconsidered for implementation.

We have genuinely enjoyed working with King County on this very interesting project. We wish to express our appreciation to Bob Bucher, Lisette Nenninger, and Mike Boyle for their tireless work in the in the coordination and hands-on operation of the Centridry™ system and the various product tests and analyses conducted over the life of the project. Likewise, we appreciate the assistance provided by South Plant staff and King County's Environmental Laboratory in this project.

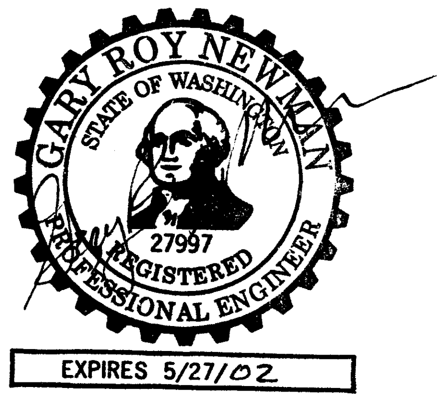
Thank you for opportunity to work with you on this project. We are available and interested in assisting in any follow-up activities associated with this evaluation.

Yours very truly,

BROWN AND CALDWELL

Gary R. Newman, P.E.
Project Manager

GRN:sjw
Enclosure



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SECTION 1

INTRODUCTION

Centridry™ is a biosolids drying process developed by Humboldt-Decanter of Germany[a]. The process uniquely combines centrifuge dewatering with flash air drying to produce a solids product with 50 to 60 percent solids, and drier. A five-month demonstration project was completed in 1998 at King County's South Plant in Renton to evaluate the technology for possible implementation at the West Point Treatment Plant (West Point) and/or South Plant. In this report, the Centridry™ process is described together with the potential advantages and disadvantages the process offers to King County. The Demonstration Project is described including the test facilities, test plan and procedures, and operating results. Data is presented on both the operation of the Centridry™ process as well as testing of the Centridry™ product in various potential beneficial use applications (including composting to Class A standards). Additional product quality and product odor control evaluation is also documented. Finally, three alternatives for full-scale implementation of Centridry™ at South Plant are evaluated against use of conventional centrifuges for dewatering.

BACKGROUND

The Centridry™ process was evaluated as part of King County's Applied Wastewater Technologies Program (AWTP). The AWTP was developed in 1991 as part of the West Point Treatment Plant Settlement Agreement. This agreement, which resolved litigation related to permits for the plant upgrade to secondary treatment, established a $5 million program to identify and evaluate technologies which offer the potential to further reduce environmental impacts at, and associated with, West Point.

Centridry™ has the potential to address many of the issues of the West Point Settlement Agreement. It would significantly reduce truck traffic since West Point currently produces a biosolid at 20 to 28 percent solids. The success of such a strategy depends on the Centridry™ technology as well as additional processing requirements and market concerns.

Haul costs to current biosolids application sites could be significantly decreased by augmenting or replacing current dewatering technologies. Both King County regional facilities currently produce Class B biosolids. West Point uses centrifuges, which produce 26 to 28 percent solids, while South Plant uses belt filter presses, which produce dewatered cake with 16 to 22 percent solids; however, the South Plant is in the early stages of a project to replace belt presses with centrifuges.

Another potential benefit of Centridry™ is the production of a biosolids product that composts more cost-effectively. Based on year 2000 estimates, King County currently sends about 7 percent of its biosolids to a commercial composter who produces a Class A product ("GroCo")[1-1]. This product is used enthusiastically by public and private landscapers and gardeners throughout the greater Seattle Metropolitan area. Conversion of more biosolids to a Class A product could expand local markets for biosolids recycling, which should reduce haul and application costs. Also,

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[a] Humboldt-Decanter is now a part of Baker Process. Baker Process retains marketing rights to the Centridry process for potential implementation at the South Plant.

converting more biosolids to Class A would decrease the costs associated with oversight of a Class B product.

King County's Centridry™ evaluation program was designed to evaluate these potential benefits, and the degree to which they can be achieved. The program included a site visit to operating installations in Europe, construction and operation of a 4.5 dry metric ton (5-TPD) per day Centridry™ demonstration facility at South Plant, bin-scale and full-scale compost studies, and a market evaluation of Centridry™ and composted biosolids using current biosolids customers and potential users. A follow-up study focused on Centridry™ product quality and controlling odors observed when the Centridry™ product is stored for a few days.

EXPERIENCE IN EUROPE AND JAPAN

The first Centridry™ system started operating on digested sludge in 1993 at Gruneck, Germany. Currently at least 18 other systems have been installed or are in design throughout Europe and Japan. These include systems designed to operate on digested sludge as well as undigested sludge. Table 1-1 provides a listing of Centridry™ systems currently in operation or design worldwide. As can be seen from the table, the Centridry™ process is being applied to many different types of biosolids, with widely varying design criteria in terms of product dryness.

Reports on the performance of the Centridry™ process, the success of various installations, and product quality piqued the interest of both King County and Brown and Caldwell engineers. To assess the credibility of these reports, site visits were made to operating installations in Germany in 1995 and 1996. Three visits were made by Brown and Caldwell representatives and two by King County representatives.[1-2] Four facilities were visited. Each was located at a municipal wastewater treatment plant, and each had been installed as a retrofit to an existing sludge dewatering process (i.e., most Centridry™ equipment was installed within existing structures). Two of the four installations operated on digested sludge while the other two operated on undigested sludge.

Several features of the Centridry™ process were identified first-hand during the site visits. Those that were most appealing to King County included: [1-3]

- Combined dewatering and drying process in a small footprint.
- Relatively simple operation requiring little operator attention.
- Dried product recycle is not necessary (as required in indirect dryer installations).
- Relatively low energy demand per ton of water removed.
- Product has good bulk handling characteristics.
- Product is aesthetically appealing compared to dewatered cake or bone-dried product.
- Low odor emissions from drying process and stored product.
- May be retrofitted into existing biosolids processing facilities.

If Centridry™ performance observed in Europe could be replicated at King County facilities, then the features described above would benefit King County through reduced operating costs and simplified biosolids management through the production of a valuable product.

Table 1-1. Centridry Installations (Existing and Planned) Worldwide

Installation	Application	Size Designation	Capacity		Design Performance		Start-up
			Liquid, gallons per minute	Solids, pounds per hour	Liquid feed, percent total solids	Dried Product, percent total solids	
Gruneck, Germany	Municipal	CD1-1.1	33	900	5.5	60	1993
Zellhof, Austria	Municipal	CD3-0.1	66	990	3	60	1995
Duisberg, Germany	Municipal	CD3-0.1	75	940	2.5	60-90	1995
Kemco, Japan	Industrial and Municipal	CD1-1.1	22	330	3	60	1995
Hiddenhausen, Germany	Municipal	CD3-0.1	66	1320	4	70	1996
Vlotho, Germany	Municipal	CD1-1.1	53	790	3	90	1996
Monsanto, Belgium	Industrial	CD3-0.1	44	440	2	90	1996
Schwaz, Austria	Municipal	CD1-1.1	27	530	4	60	1997
Barr Degremont, France	Municipal	CD1-1.1	29	500	3.5	65	--[b]
Vienna, Austria	Municipal	CD4-1.1	110	2200	4	80	1997
Oviedo, Spain	Municipal	CD-3074[a]	110	2200	4	70	--[b]
Frederiksharn, Denmark	Municipal	CD-3054[a]	110	1100	2	60	1998
Hyogo, Japan	Municipal, Industrial	CD1-1.1	30	450	3	50-90	1997
Limoges, France	Municipal	CD-3084[a]	130	2000	3	60	2000
Megeve, France	Municipal	CD1-1.1	18	440	2	60	--[b]
Sarrebours, France	Municipal	CD-3034[a]	13	400	6	65	--[b]
Beaufortain, France	Municipal	CD-3034[a]	9	350	8	65	--[b]
Estempes, France	Municipal	CD-3034[a]	24	520	3.5	65	--[b]

All data provided by Humboldt or Baker Process (current as of November 2001).

[a]Humboldt's size designation. Humboldt changed model numbering scheme in 1997.

[b]In design or construction--not yet started.

KING COUNTY DEMONSTRATION PROJECT

Based on the site visits, King County's Applied Wastewater Technologies Program concluded that the Centridry™ technology had sufficient potential to justify a substantial demonstration project. A 4.5 dry metric ton per day (5 TPD) Centridry™ facility was selected for the demonstration project to provide sufficient biosolids product for testing in a variety of existing biosolids markets and composting studies. A facility of this size would also provide a sound engineering basis for evaluating potential scale-up to full-plant capacity.

Implementing the Centridry™ Demonstration Project was a complex undertaking requiring a substantial investment of time and energy from several organizations within, and outside of, King County. Some of the key activities and supporting organizations are listed below:

- Demonstration Facility construction – South Plant Engineering, Technology Assessment Program (formerly Advanced Wastewater Technology Program).
- Facility startup, troubleshooting, and optimization - Humboldt, South Plant Operations, Technology Assessment Program (formerly Advanced Wastewater Technology Program).
- Demonstration Facility operations – South Plant Operations and Process Control, Technology Assessment Program (formerly Advanced Wastewater Technology Program).
- Centridry™ product distribution and existing market assessment - King County Biosolids Management Program.
- Composting bin tests - E&A Environmental Consultants, King County Environmental Lab, South Treatment Plant Process Lab.
- Commercial compost testing - King County Biosolids Management Program.
- Centridry™ product analytical testing - King County Environmental Lab, South Treatment Plant Process Lab.
- Stack air emissions testing - Amtest.
- New market assessment - Norton-Arnold and Janeway, Inc.
- Structural evaluation of existing Dewatering Building for Centridry™ equipment - Symonds Consulting Engineers.
- Documentation of Centridry™ Demonstration Project Conclusions, and life-cycle cost evaluation - Brown and Caldwell.

Many of these activities were proceeding concurrently. Planning and coordinating were key to gaining meaningful results from the Demonstration Project. The AWTP, namely Mr. Bob Bucher, was responsible for overall project coordination and planning. Mr. Bucher was assisted by Messrs. Mike Boyle and John Smyth of the AWTP.

CENTRIDRY™ PRODUCT EVALUATION

The results of the King County Demonstration Project indicated that the process is capable of producing biosolids of fifty to sixty percent solids content in a mechanically reliable and operator-friendly manner. On the other hand, the results also indicated that there could be serious issues of odor, and hence product acceptability, associated with the Centridry™ product. The issue of product odor was judged to be a "watershed" issue for the viability of Centridry™ at the South Plant. Consequently, King County elected to focus additional effort on the evaluation of the Centridry™ product. Specifically, a follow-up study was performed with the following objectives:

1. Identify the causes of product odor.
2. Identify methods of controlling odors as product ages.
3. Evaluate composting of unamended Centridry™ product to Class A biosolids criteria.
4. Evaluate the feasibility of treating composting off-gases with biofiltration.
5. Evaluate the potential for beneficial reuse of composted product by end users.

The approach used in this follow-up study included the following activities:

1. Brainstorming workshops, utilizing expertise of scientists currently and actively engaged in biosolids and microbiological research.
2. Prioritized field trials to test the hypotheses developed in brainstorming sessions for cause and potential control of Centridry™ product odors.
3. Product composting tests, followed by limited product evaluation.
4. Developing and evaluating alternatives for full-scale Centridry™ implementation, incorporating the results of activities 1, 2, and 3 above.

Brown and Caldwell and E&A Environmental Consultants (now Tetra Tech, Inc.) assisted King County in this Centridry™ Product Evaluation Study. King County, specifically Ms. Lisette Nenninger, was responsible for generating Centridry™ Product (with assistance from Baker-Hughes), planning and conducting the field tests, and coordinating composting and biofiltration tests. Brown and Caldwell and E&A Environmental coordinated the brainstorming sessions, assisted in field tests and composting tests as requested, developed and evaluated alternatives, and documented results.

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SECTION 2

DEMONSTRATION PROJECT: PLANNING AND SETUP

The Centridry™ Demonstration Project represents a significant investment in capital, time, and personal energy on the part of the King County and Humboldt participants. The paragraphs below describe the Centridry™ system installed as well as the planning and activities associated with constructing, starting, and operating the system.

OBJECTIVES

The demonstration project was designed to meet five primary objectives:

1. Evaluate operability and reliability. To be successful, the system must operate reliably and safely without constant operator attention, and recover readily from planned and unplanned system shutdowns.

2. Assess product quality and acceptability to current and new markets. To be successful, the final biosolids product must be desirable to current markets or suitable for developing strong new markets.

3. Assess potential for odor production and air emissions. To be successful, the process must operate without production of significant odor and adverse air emissions.

4. Assess ability to compost product to achieve a Class A material. The ability to achieve a Class A product through composting is important for expanding current and developing new Class A markets and desirable for existing Class B markets.

5. Assess operating costs to determine cost-effectiveness at full-scale operation. To be successful, the process must provide system-wide benefits/savings commensurate with capital and operating costs.

This project was a collaborative effort between King County, Humboldt and a consultant team headed by Brown and Caldwell Consultants. King County personnel were principally responsible for directing and conducting the project study, and operated the facility during the test period. Humboldt was responsible for construction and start-up of the demonstration facility, as well as operations training and troubleshooting during the operating period. A consultant team headed by Brown and Caldwell provided technical assistance for all phases of the Demonstration Project. E&A Environmental Consultants, Inc. was also on the consultant team; E&A focused on the compost studies. In addition, Norton-Arnold and Janeway, Inc., provided assistance in evaluating the new market potential of the Centridry™ product, and Symonds Consulting Engineers, Inc., provided structural design and evaluation services.

TEST PLANNING

A key to the success of the Demonstration Project was thorough planning by all parties at the outset of the facility implementation.

Process

A test plan was developed as a guideline for the Centridry™ demonstration test period. The plan outlined test objectives and operating conditions, a sampling plan, and operation responsibilities. After the startup phase, King County Operations was assigned responsibility for the day-to-day operations of the demonstration facility. Humboldt representatives were available as necessary to assist King County with operations and troubleshooting.

The process was operated with a digested solids feed for the majority of the project. Two weeks at the end of the demonstration were devoted to the processing of undigested sludge (70 percent primary, 30 percent secondary). Process parameters were recorded and samples collected for analysis. Sampling was conducted in accordance with a detailed sampling plan developed by King County. Sample analysis provided critical information to define dewatering and drying efficiency, process mass balances, energy consumption, polymer consumption, product quality, sidestream quality, and air emissions.

Product Composting

A test plan was developed to guide the study of the composting characteristics of the Centridry™ product. The objective was to determine the requirements to compost Centridry™ biosolids to a usable Class A product. The study was designed to determine the suitability of the Centridry™ product to self-compost, assess the performance of several bulking agents and mix ratios, and evaluate final product characteristics, e.g. pathogen count, nutrient value, moisture, texture, etc. Pilot-scale composting trials (one cubic yard bins) were performed at South Plant to evaluate various operating and performance parameters (e.g., air requirements, percent and type of bulking agent, etc.) for optimum composting and minimum odor production. Centridry™ biosolids were also hauled off site to privately-owned composting facilities for full-scale composting trials.

The bin testing program was used to improve knowledge about a large number of alternative composting options while requiring limited space and supporting resources. The following issues were evaluated during bin testing:

1. Adequacy of moisture available in the Centridry™ product to qualify as a Process to Further Reduce Pathogens (PFRP) and produce a stable compost product.

2. Availability of sufficient energy (degradable organics) to qualify as a PFRP and Vector Attraction Reduction process (VAR).

3. Extent of nitrogen loss when composting dried solids without a bulking material.

4. Suitability of the Centridry™ product texture for aeration without bulking material addition.

5. Extent of active composting (biologically degrade) versus heat retention through product insulative properties.

6. Bulking material usage for moisture, energy, or texture enhancement of the dried product.

7. Odor associated with the uncomposted product in a dried and rewetted state.

8. Odor associated with composting.

9. Density characteristics of the Class A products and transportation cost implications.

10. Potential for compliance with VAR considering 40 CFR 503.32(a)(2) which requires Class A to be achieved prior to or at the same time as VAR.

See Appendix C-1, Evaluation of Class A Compliance Alternatives for Centridry™ Product.

Product Distribution

The King County Biosolids Management Program was responsible for investigating application equipment appropriate for the Centridry™ product, and the Centridry™ product's suitability for current biosolids application sites and contracts. Application sites include forest fertilization on state and Weyerhaeuser forest land, dryland wheat fertilization in Douglas County, fertilization of hops in Yakima County, and composting with GroCo and Land Recovery, Inc. (LRI). [In the report sections that follow, the experience gained from GroCo and LRI will be discussed under Product Composting.] Each of the sites was selected to receive the Centridry™ product for testing, and project sponsors or application contractors were asked to provide an assessment.

FACILITY INSTALLATION

The Demonstration Project facility included a 5-dry-tons-per-day, production-scale Centridry™ system, equivalent in capacity to systems currently in operation in Europe serving small treatment plants. Thus the process train and the individual components were representative of a full-size Centridry™ system if implemented at South Plant. Also, the Demonstration Project facility was sized large enough to generate sufficient product for evaluation in various potential beneficial use applications.

Process Hardware

All process hardware was shipped from Germany in September 1996. Installation of the hardware was completed by Humboldt representatives from January to April, 1997. Figure 2-1 depicts the process schematically and is followed by a description of the major system components.

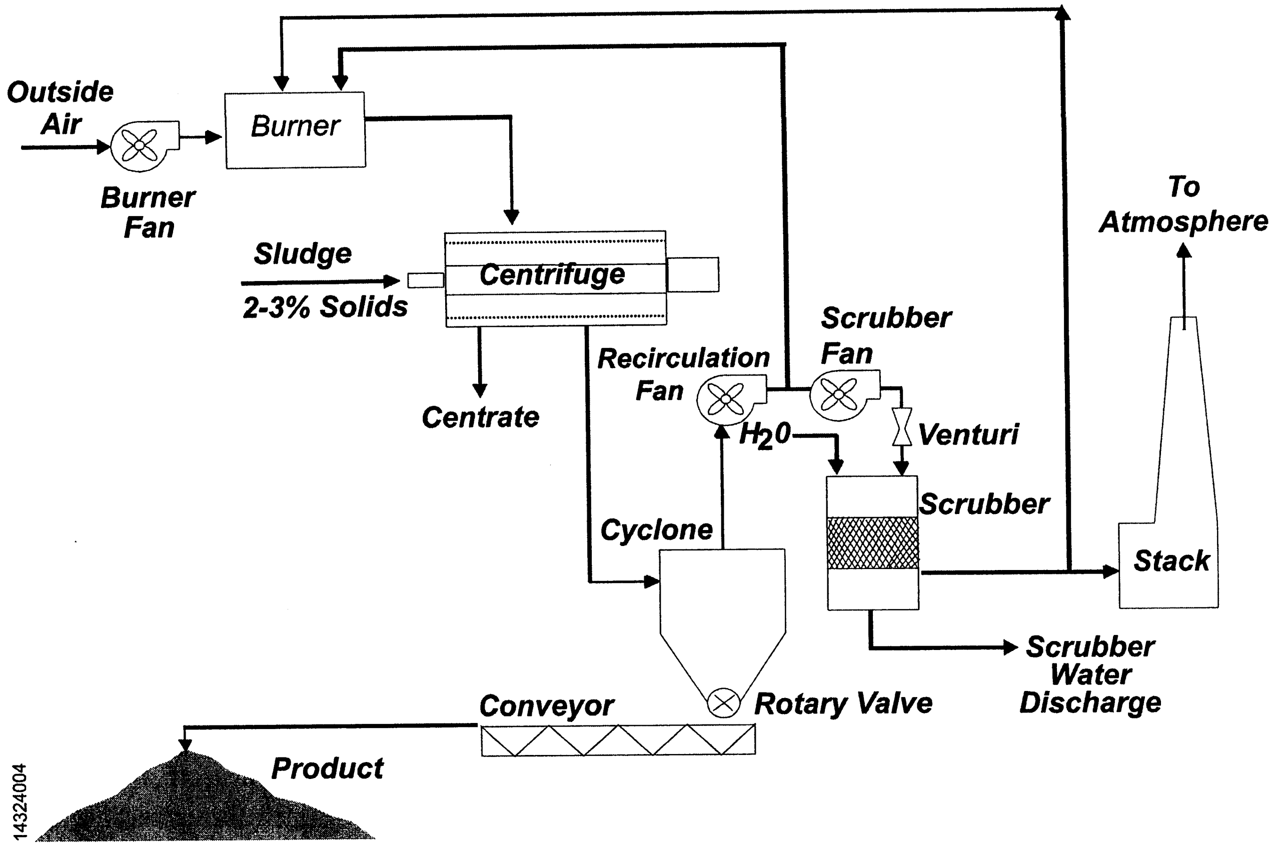

Figure 2-1. Centridry™ Demonstration Project Process Schematic

Centrifuge. A high solids centrifuge (Humboldt Centripress series) is used for mechanical dewatering. The centrifuge discharge is modified to promote "splattering" of the dewatered sludge solids into small particles. These smaller particles are discharged to an insulated shroud through which hot air is blown. The small particles are entrained in the hot air stream, promoting quicker, more efficient drying. Polymer is added to the sludge feed prior to dewatering as is done for conventional centrifuge dewatering. Centrate is routed from the centrifuge as with any conventional centrifuge.

Hot Air Drying. Hot air is blown through the insulated shroud surrounding the centrifuge to entrain the dewatered solid particles. The hot air temperature through the shroud is about 200°C (390°F). Upon contact with the hot air, the moisture on the surface of the particle evaporates. The air and particles are pneumatically conveyed through insulated stainless steel piping to a cyclone separator. Additional drying occurs in transit to the cyclone. The "flash drying" transfers only limited heat to the solids particles. The temperature of the solid particles at the process discharge is about 50°C (120°F) with the cyclone air temperature at about 140°C (285°F).

Burner. A conventional burner is used to produce a 200-300°C (390-570°F) air stream. Various fuel types can be used in the burner including digester gas, heating oil, natural gas, or propane. Propane was used for the South Plant demonstration facility because of the facility's temporary nature. Hot air from the burner is mixed with recycled air prior to entering the centrifuge. The hot gas-burner system is controlled to maintain a constant inlet temperature to the centrifuge.

Hot Air Recirculation. An induction or recirculation fan provides the energy for moving the hot air stream from the centrifuge shroud through the cyclone separator. Located downstream of the cyclone, the recirculation fan recycles a portion of the hot air to the burner's discharge while the remainder is cleaned via the scrubber/packed bed. Dampers on the recirculation fan's discharge control the percent of air recycled vs. the percent scrubbed. The recycle loop is designed to reduce energy consumption by recycling a portion of the thermal energy.

Cyclone Separator. Dried sludge particles are separated from the hot air stream via a cyclone separator. The recirculation fan draws the solids-carrying air stream from the centrifuge to and through the cyclone. Velocities from the centrifuge to the cyclone are on the order of 50 to 60 feet per second. A rotary valve at the bottom of the cyclone discharges the dried particles to a screw conveyor for discharge to the receiving truck or bin.

Scrubber Exhaust System. Particles not captured in the cyclone are removed from the air stream in the scrubber system. This scrubber system also provides a degree of odor and air emissions control. The scrubber system includes a scrubber fan, a Venturi scrubber and packed bed, and an exhaust stack. The scrubber fan directs a portion of the hot air stream through the scrubber/packed bed. Water (South Plant effluent) is injected both at the Venturi throat and at the top of the packed column. A portion of the scrubbed air discharge is recycled to the burner to control the oxygen content in the hot air stream and balance the system operating pressure. The remaining scrubbed air is discharged to the atmosphere via a stack.

Process Control Hardware. A programmable logic controller (PLC) monitors key process parameters, reports and responds to alarm conditions, and provides automated process startup and shutdown. A data acquisition system (DAS) operates via a software package to provide data logging and trending capabilities. The DAS has the capability of being accessed via modem for on-line monitoring at Humboldt offices in the U.S. and Germany.

Building

A steel building was constructed to house the 5-dry ton per day Centridry™ process hardware. The 25-foot tall building with a footprint of 1,200 square feet accommodated all of the hardware except the cyclone separator and associated piping. The product loadout area was also protected by roof overhang on the front of the building.

Utilities

Mechanical utilities supplied to the pilot plant included potable quality water (C2) for the polymer system, flushing, and general cleanup, secondary effluent for the scrubber system, service air for instrumentation and cleaning, a sludge supply capable of delivering digested or undigested solids, and propane gas from temporary bulk storage tanks. Facility electrical utilities include two 200 amp, 480V feeders, and 60 amp, 120/208V service. Data required for process evaluation was collected via the DAS and automated samplers installed in the solids feed supply, centrifuge centrate drain, and scrubber condensate drain piping.

TAB

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SECTION 3

DEMONSTRATION PROJECT: OPERATING EXPERIENCE

The Centridry™ Demonstration Facility was first placed into operation in spring of 1997. The initial months of operation were spent by Humboldt optimizing the system and resolving process and mechanical issues as they were discovered. The actual period of operation extended from September 1997 through March 1998. The following paragraphs summarize the experience gained from the Centridry™ startup, process optimization, and steady-state operating periods, as well as the concurrent composting evaluation and the Centridry™ product market assessment. The results of the follow-up Centridry™ product evaluation are discussed in Section 4.

CENTRIDRY™ PROCESS

The following paragraphs discuss the three primary phases of Centridry™ operation: startup, optimization, and steady-state operation. Operating data is presented for operation on digested solids, and a discussion of operation on undigested solids is also provided.

Startup

The agreement between King County and Humboldt required that Humboldt successfully demonstrate the reliable operation of the Centridry™ system, and provide operational training prior to the initiation of the steady-state operational test. Humboldt representatives from Germany and the United States initiated hardware checkouts in May 1997.

Equipment start-up during the first weeks of May was successful; a 60 percent product was attained the first day. However, solids capture was poor as evidenced by the centrate quality. Attempts to improve capture merely resulted in poor product quality. A two-sided approach was taken to address this issue. First, polymer trials were carried out to find a polymer that would improve the low shear resistance of the South Plant digested solids. The "soft" digested solids produced by South Plant are uncharacteristic of solids that Humboldt had seen at other installations. Though somewhat successful, changes in polymer and polymer doses were less than optimal. Second, the centrifuge's conveyor scroll was reconfigured to improve mechanical dewatering. After the conveyor assembly was reinstalled in the centrifuge, further polymer trials were carried out. Along with updates to the software control logic, the scroll adjustment and selection of an effective polymer markedly improved capture efficiency. Humboldt representatives were in the lead during these initial optimization steps.

To verify the mechanical dewatering efficiency of the Centridry™ centrifuge, Humboldt conducted dewatering trials using a centrifuge pilot trailer. The centrifuge in the pilot trailer was the same model as the Centridry™ centrifuge. Using the same feed solids and polymer dosing, the pilot trailer centrifuge consistently produced a dewatered cake in the range of 27-28 percent TS. This provided critical polymer dosing information and centrifuge operation criteria for baseline operation of the Centridry™ centrifuge. By contrast, South Plant's belt press dewatered cake was 20 to 21 percent total solids during this mechanical test.

Optimization

Start-up events highlighted the difficulty and importance of optimizing the mechanical dewatering portion of the process. Inadequate mechanical dewatering can (and did) produce wet, coarse particles, which require more heat to dry, and can (and did) accumulate and clog downstream equipment. In fact, several shut-downs were required to "unclog" various parts of the system during start-up.

The integral design of the centrifuge discharge with the hot air entrainment makes it difficult to obtain a mechanically dewatered sample. Thus, other parameters were used to indicate how well feed solids were mechanically dewatering. Centrate quality initially was the only parameter monitored to indicate mechanical dewatering performance. Experience showed that other parameters, specifically, the differential air temperature across the centrifuge and the pressure on the hydraulic back drive, provide more reliable "real-time" indication of dewatering performance than centrate quality. This monitoring approach and the polymer dosing selected from dewatering trials provided the tools to better operate the facility and respond to varying sludge and polymer conditions.

The burner unit operating temperature was selected as the parameter to control the final product percent TS concentration. Following the optimization of the centrifuge, trials were conducted to document the impact of the burner temperature setpoint on the final product characteristics (primarily percent TS). An operating temperature range was defined to produce a final product with a range between 55 and 60 percent TS.

Steady-State

The official operation period started the first week of September, 1997. From late September through December, continuous operation was not achieved due to impacts from South Plant construction activities and a mechanical issue with the Centridry™ air conveyance system. With the help of Humboldt, mechanical problems were solved, and the demonstration facility moved to continuous operation in early January, 1998. The process operated continuously from January through March, 1998. Throughout the demonstration testing, Humboldt representatives supported the ongoing operation of the demonstration hardware and training of operations personnel. This close working relationship allowed continuous process operation that satisfied the objectives of the demonstration project.

The Centridry™ system was initially operated with a goal of running 24 hours per day, 7 days per week. After several weeks of inconsistent operation and difficulty in scheduling biosolids trailers, the decision was reached to switch operation from 7 to 5 days per week. Operations shift crews were responsible for several tasks during process operation. Tasks included monitoring solids loading into the staged biosolids trailer, trailer removal and replacement as required, collection of product grab samples, and completion of a daily checklist. The performance of these tasks required approximately one hour of time during a 12-hour shift.

A major drawback in the operation of the pilot plant involved the loading of product into staged biosolids trailers. This required manually moving a product discharge screw conveyor to distribute the material uniformly in the trailer. In addition, rakes were used to spread the product in the trailer. This activity required more attention than any other aspect of operating the Centridry™ system. Improvement of the product discharging mechanism would have further streamlined the operation.

The startup and shutdown of the Centridry™ system were handled automatically by computer sequencing. Individual system components could also be operated manually. During operation, critical system parameters were monitored and recorded by a programmable logic controller (PLC) and abnormal operation was displayed on a local alarm panel. The Centridry™ system centrifuge was controlled in the same manner as any normal dewatering operation. The process air conveyance system was operated by the PLC. The burner and polymer systems were setup and operated at local control panels. The solids feed rate and polymer feed rate were input into the PLC. Burner controlling temperature was input at its local panel. Centrifuge operating parameters were input at its backdrive controller.

Process samples (24 hour composites) were collected on a daily basis from four sample locations: solids feed, centrate, condensate, and product. The South Plant Process Control Laboratory provided daily conventional analysis of the samples and the King County Environmental laboratory was sent a weekly sample for metals and biological analyses.

Operating Data - Digested Solids Processing

From September 1997 through March 1998, 442 wet tons of Centridry™ product was produced. Product dryness commonly fell in the 50-65 percent total solids range, with 55 percent as a target. It can be characterized as slightly moist, with fine particles and little odor. Product as wet as 45 percent solids and as dry as 80 percent was produced. The wetter product was an attempt to generate a product that more easily composts. The drier product was generated to test the limits of the process and was observed to result in considerable dust formation.

Product odor was observed to increase significantly with storage (in truck trailers or large piles) for more than a few days.

Tables 3-1, 3-2, and 3-3 present operating data, product characteristics, and air emission data during continuous steady-state operation as defined in Appendix B. In general, the facility successfully demonstrated the ability to produce a dried biosolids product in the 50-60 percent solids range. Polymer use was higher than expected - nearly 32 lb/DT rather than an anticipated 20 lb/DT. (It should be noted that South Plant's belt press dewatering process has historically required high polymer dosage for effective dewatering; e.g., the 1997 average polymer dosage was 25 lb/DT[3-1]). Centrate quality and solids capture were in the range of values expected. The hot air burner, recirculation system, and exhaust scrubber system performed well.

Table 3-1. Centridry™ Operating Data

Process parameter	Average value
Solids feed flow, gpm	27
Feed solids, percent	2.9
Solids capture, percent	88
Polymer use, lb active/dry ton[a]	32
Centrate TS, mg/L	1,632
Scrubber water TS, mg/L	308
Burner setpoint, °F	350
Electrical requirement, KWH/lb dry solids	0.37
Dryer energy requirement, BTU/lb H_2O evaporated	1,583

[a]Polymer usage expressed as lbs active polymer.

NOTE: Data based on steady-state operation as defined in Appendix B.

Table 3-2. Centridry™ Biosolids Product Characteristics

Parameter	Average value
Product, % TS	60
Product bulk density, lb/cu yd	975
Volatile solids, % of TS	61
pH	8.6
Ammonia, mg/Kg, dry as N	7,371
TKN, mg/Kg, dry	51,636
Total P, mg/Kg, dry	20,053
K, mg/Kg, dry	1,678
Fecal coliform, MPN/100 grams, dry	805
Salmonella, MPN/100 grams, dry	< 3

Notes:

1. Metals (Arsenic, Cadmium, Copper, Lead, Mercury, Molybdenum, Nickel, Selenium, Zinc) all measured below 40 CFR Part 503 regulated levels.
2. Data based on steady-state operation as defined in Appendix B.

Table 3-3. Centridry™ Stack Air Emissions Data [1]

Parameter	Average value
Air flow, cfm	641
Exit temperature, °F	57
Total particulate matter, grams/dscf	0.0028
O_2, % by volume	14.7
SO_2, ppm	0.5
NO_x, ppm	15.6
CO, ppm	46.9
Total hydrocarbons, ppm, dry	95.0

[1] Collected during February 1998 operation (six sampling events)

Undigested Solids Processing

The final two weeks of the demonstration project were spent processing undigested solids (digester feed material). Early success in processing the undigested sludge revealed a product with a much larger particle size compared to the digested product. In addition, some particles were recognizable with respect to their origin, e.g., paper. Odor levels in the exhaust stack during processing were controlled and not unlike the processing of digested material. The odor associated with the undigested product was different but not objectionable. Continuous processing of undigested sludge was not achieved due to problems in attaining the proper polymer dosing. Time constraints did not allow additional polymer trials to be conducted.

PRODUCT COMPOSTING

The following paragraphs provide an overview of the composting trials conducted using Centridry™ product. A description of the test bins is provided followed by a summary of results. See Appendix C-1, Evaluation of Class A Compliance Alternatives for Centridry™ Product, for a more complete description of the composting trials and their results.

Compost Bin Setup and Operation

Eight different mixes using Centridry™ wastewater solids alone or with selected bulking materials were composted in four aerated 0.6 cubic meter capacity composting bins. A cement mixer was used to mix the bulking materials and wastewater solids. The mixes were then manually loaded into the bin composters. The mixes were composted for at least 21 days. Temperature was maintained within optimum levels using a temperature feedback controller on the aeration system. The system was operated to achieve 55°C or warmer for 3 days to comply with the Process to Further Reduce Pathogens (PFRP). The bins were controlled to provide compliance with Vector Attraction Reduction (VAR) per EPA 40 CFR 503.33(b)(5) which requires temperatures greater than 40°C for 14 days with an average greater than 45°C.

During the two week bin composting studies, composting material samples were analyzed for process status parameters. Odor emissions were monitored during composting using colorimetric tube and odor panel analyses. The odor panel analysis was completed by a seven person panel using ASTM consistent equipment, sampling and measurement procedures. At the end of the composting process, the volume and weight of product was determined.

The test mixes were selected based on experience with the product in Europe, traditional approaches to composting, and consideration of innovative methods of complying with Alternative 1 (Time and Temperature) of the Pathogen requirement of 40 CFR 503.

Experience in Europe with static pile composting of the dried product indicates the possibility that sufficient heat is released by the newly dried product to maintain composting temperatures in static unaerated piles. Aeration was found to cool the piles below required temperatures. The rate of aeration at which over-cooling occurs was not indicated. Sufficient energy appeared to be provided by a Volatile Solid (VS) reduction of 12 percent. The remaining moisture in the material tested in this manner resulted in a 60 percent TS content. During 3 months of storage, the solids had sufficient energy to further dry the product to 75 percent solids.[3-2] Based on this experience, it was desirable to use the bins to better define the conditions under which this approach could be used.

Traditional composting of dewatered biosolids typically involves the addition of a bulking material to condition the mix for effective biological activity and the provision of a moist, aerobic environment. Drying the solids to the levels achieved by Centridry™ significantly changes the physical characteristics of the solids and the need for a bulking material to increase the solids content of the mix into the ideal range for composting. In fact, Centridry™ product is normally drier than desirable for composting. With this dry product the use of a bulking material would condition the mix in different ways than normally expected. A goal in developing the recommended initial mixes was to test different bulking material ratios in order to evaluate whether the bulking material mixes outperform the dried product by itself. Inadequate moisture impedes biological degradation because of the need for water by the microbial population. European experience indicates heating and VS reduction at 60 percent TS, but no information is available to document performance at this moisture content relative to composting of dewatered biosolids. There is also no information on the impact of a more moist mixture, or the impact of providing a bulking material. The following mixes were used to address these issues during bin testing.

Series 1, Digested Solids Feed:

- Bin 1, 100 percent Centridry™ product without aeration - This models the European experience as closely as possible using South Plant biosolids.

- Bin 2, 100 percent Centridry™ product with aeration - This models the aeration experiment conducted in Europe but with highly controlled aeration rates.

- Bin 3, 33 percent Centridry™ product (2:1 mix) and 67 percent coarse, moist sawdust bulking material with aeration - This models the aerated static pile process using sawdust as the bulking (and moistening) material. The mix ratio includes less sawdust than used in traditional composting, but provides enough to identify any positive benefit of adding sawdust.

- Bin 4, 43 percent Centridry™ product, 43 percent coarse, moist sawdust bulking material, and 14 percent thickened undigested wastewater solids (1:1:1/3 mix) with aeration - This mix models the aerated static pile process using sawdust as the bulking material and thickened solids for moisture addition and micro-organism seeding. The seeding was felt to be potentially beneficial for odor control by replacing desired micro-organisms lost in the drying process.

Series 2, Digested Solids Feed:

- Bin 1, 100 percent Centridry™ product without aeration - Replicate of Bin 1 – Series 1.
- Bin 2, 100 percent Centridry™ product with aeration - Replicate of Bin 2 - Series 1.
- Bin 3, 33 percent Centridry™ product (2:1 mix) and 67 percent coarse, moist sawdust bulking material with aeration - Replicate of Bin 3 - Series 1.
- Bin 4, 100 percent Centridry™ product that was held in unaerated storage for three weeks, with aeration - Replicate of Bin 1 - Series 1 using aged material to evaluate the effects of storage prior to composting.

Compost Bin Trials

The performance of the bins indicates that the Centridry™ product, with and without bulking materials, generates temperatures that are required for regulatory compliance. Significant odors were found to be generated during initial mixing and placement of the material and during composting. The second series of bin trials used Centridry™ product that had a 5 percent lower moisture content than the first series. There was some indication that the reduced moisture content may have slowed the composting process and reduced operating temperature in the 100 percent Centridry™ product bins.

In all mixes, organic nitrogen was being converted to ammonia. Ammonia comprised 33 percent to 48 percent of the TKN in the mixes after 35 days. Most of the ammonia was held in the mix despite the low C:N ratio, high pH of 8.0 to 8.7, and increased ammonia concentration. The straight product bins experienced significantly less nitrogen loss than the mixes with bulking agent. The pathogen data indicated that all bin mixes complied with both the Salmonella and Fecal Coliform requirements for Class A.

Commercial Composting Setup and Operation

Full scale commercial composting tests were conducted by Land Recovery, Inc. (LRI) and GroCo, Inc. See Appendix C-1, Evaluation of Class A Compliance Alternatives for Centridry™ Product, for more complete discussion of the full-scale composting operation.

Land Recovery Inc. (LRI) Full-Scale Trials. LRI currently operates the Pierce County Yard Debris Composting Facility at Purdy, WA and a NatureTech Bin System at the Hidden Valley Transfer facility located near Puyallup, WA. The NatureTech system uses modified drop boxes and an automated aeration system to provide a temperature controlled composting environment. LRI tested the Centridry™ product in the aerated drop box bin system.

LRI tested five mixes:

- 2:1 by volume yard debris : Centridry™ product
- 4:1 by volume yard debris : Centridry™ product
- 3:1 by volume sawdust : Centridry™ product
- 3:1 by volume sawdust : dewatered biosolids
- Centridry™ product only

GroCo (Sawdust Supply) Full-Scale Trials. GroCo has been composting dewatered biosolids from generators in the Seattle region for over 25 years. GroCo, located in Kent, WA. uses the large static pile method of composting a mix of 1 part by volume dewatered biosolids with 3 parts sawdust. GroCo tested the Centridry™ product in static piles.

GroCo tested three mixes:

- 4:2:2 mix by volume of sawdust; dewatered biosolids; and Centridry™ product
- 3:1 mix by volume of sawdust and Centridry™ product
- 2:1 mix by volume of sawdust and Centridry™ product

Commercial Compost Product Testing

A portion of the composted product from LRI and Groco was analyzed for various parameters that impact plant growth, including nutrients, metals, pH, bulk density, volatile solids, and phytotoxicity. The results of these tests are provided in Appendix C-2.

In general, these tests indicate that the Groco product (which included bulking agent in ratios of 2:1, 3:1, and 4:2:2 sawdust to Centridry™ product), exhibited good plant growing characteristics, with generally high quality ratings in terms of nutrients, pH, organic content, carbon to nitrogen ratio, dissolved solids, and other parameters. The product was also observed to have no odor, and no phytotoxicity.

The LRI material tested was a composted Centridry™ product only sample. The results of these tests indicated that this product also exhibited generally good characteristics with respect to constituents, with the exception of pH, which was relatively high. However, the LRI Centridry™ only compost product was observed to have high phytotoxicity and a strong odor.

The results of these three tests raise questions regarding the marketability of a Centridry™ only compost product. Further tests were conducted to more thoroughly assess the physical, odor, and application, characteristics of the Centridry™ only compost product (see Section 4).

Additional Microbiological Data

Microbiological evaluation of the Centridry™ product was conducted periodically throughout the 4-month demonstration project. With respect to fecal coliform, the Centridry™ product always met requirements for Class B standards. Analysis for salmonella generally yielded results of less than 3 MPN/100 grams dry product.

In July of 1998, however, the Centridry™ system was operated in order to generate some additional product for compost testing by LRI. Samples taken by the King County Environmental Lab during this production run differed significantly from previous samples in that salmonella counts were extraordinarily high. Analyses conducted on 3-day old samples (refrigerated) showed salmonella counts greater than 1600 MPN/gram wet (1600 was the measurable range limit established for this sample). After an additional 8 days of unrefrigerated sample storage, salmonella was measured at 130,000 MPN/gram wet. In addition, samples taken by LRI were evaluated by the King County Environmental Lab and were also found to have extremely high salmonella counts--46,000 MPN/gram wet. The results of this microbiological evaluation of the Centridry™ product are summarized in Appendix C-3.

Given the unusual results relative to the other microbiological tests conducted during the demonstration project, and the extraordinarily high values recorded from these samples, a group of King County staff, representing the AWTP, the Environmental Lab, and the Biosolids Management Program, met to review and evaluate the results. With respect to these results, the group agreed on the following:

- King County's Environmental Lab had never seen salmonella counts at this level.
- It would be difficult, if not impossible, to contaminate a sample to this degree by mishandling the collection.
- There was no obvious explanation for the high salmonella values.
- Product wetting and subsequent regrowth was considered a potential cause.
- More extensive testing is necessary to evaluate product handling and potential causes for the elevated salmonella counts.

A high potential for pathogen regrowth would be a serious concern with respect to the Centridry™ product's acceptability in the marketplace. As a follow-up to this meeting, the "regrowth potential" of Centridry™ product was tested under several conditions. In all cases, regrowth of salmonella could not be recreated in any way similar to that observed in the July 1998 LRI samples.[3-3] Therefore, it is concluded that pathogen regrowth in Centridry™ product is not an issue.

PRODUCT MARKET ASSESSMENT

The Centridry™ product was evaluated by current users of King County's biosolids (dewatered cake). The paragraphs below summarize comments and reactions from these users. In addition, a telephone survey was conducted to assess the new market potential of the Centridry™ product, specifically in the topsoil manufacturing market.

Existing Markets

The Biosolids Management Program coordinated the distribution of Centridry™ product to current biosolids end-users. Three end-use projects participated: (1) forest fertilization on State and Weyerhaeuser forestland, (2) dryland wheat fertilization in Douglas County, and (3) fertilization of hops in Yakima County. Each of these projects received the Centridry™ product for testing.

Each project sponsor or application contractor was asked to provide an assessment of the Centridry™ product. In general, biosolids users who tested the Centridry™ product provided negative comments, largely because of the odor and dust associated with the product. In each case the comments were that because each of these projects operates in close proximity to "neighbors," either homes or other non-biosolids operations, the odors from the product may jeopardize the projects. Also, the equipment operators and other laborers who worked around the product were concerned for their safety from the dust created when the product was applied and from the odor that was associated with the product. The hops project, for example, supplied their workers with respirators to address workers' concerns while working with the product.

Table 3-4 summarizes comments received from project sponsors or application contractors regarding the Centridry™ product.

Table 3-4. Summary of Current Biosolids Users' Comments Regarding Centridry™ Product

End-use site	Users' overall assessment	Unloading and loading	Dust	Odor	Spreading
Forest	Unacceptable	Okay but dusty	Excessive	Sharp	Poor (50 ft)
Wheat	Unacceptable	Dusty and odorous	Excessive	Terrible, odor lingered after tilling into soil	Difficult
Hops	Unacceptable, unsafe workplace	Too dusty: Tried wetting, but too expensive	Excessive	Extremely offensive, cannot contain odor	Required masks and respirators

The paragraphs below provide additional information regarding the assessment of the Centridry™ product in King County's existing biosolids beneficial use markets.

Forest. Loads were received in January and February 1998. Although the trailers unloaded easily, there was airborne dust and a sharp odor during unloading. The product loaded into the spreader easily, but anytime the product was disturbed, dust was created. The spreader was able to fling the material only about 50 feet versus the cake product, which can be flung over 200 feet. On a typically windy and gusty day at the application site, the material was observed to swirl around the applicator vehicle, covering it with the dust.

A small portion of the Centridry™ product was pelletized to determine whether its "flinging" characteristics could be improved. The Centridry™ product appeared to be amenable to pelletizing, and the pelletized product was also tested on forest land. It could be flung over 100 feet with little or no dust, but the odor characteristics were similar to the other Centridry™ product.

Wheat. Loads were received in June and July 1997 and in January, February and March 1998. The project sponsor expressed concern with the Centridry™ product due to dust and odor during delivery, while spreading, and after it was tilled into the ground. Application of the product was limited to sites away from roadside neighbors due to odors. Sponsors were concerned about jeopardizing the local acceptance of the biosolids project because of the odor associated with the Centridry™ product.

Hops. Loads were received in fall 1997. The problems encountered with the Centridry™ product were excessive dust, odor and increased cost of handling. At one location, workers were given mask/respirators because of safety concerns due to excessive dust. To control the dust associated with the product during loading and to facilitate loading, water was sprayed on the product. This was judged to be an inefficient process both physically and financially. Because the product had a lower nitrogen rate per dry ton, an increased rate of application was required, which reduced efficiency in handling. Odor from the Centridry™ could not be contained and was judged to be offensive. Because the Green Valley area is interspersed with many non-farmers, the odors from the Centridry™ product could easily jeopardize the acceptance of the project.

Potential New Markets

One of the potential benefits of the Centridry™ process is the creation of a product that could open new markets for King County's biosolids. The incentive to King County for developing new biosolids products are: (1) additional markets potentially create more demand for biosolids in the beneficial use marketplace which further ensures that King County will always be able to fully distribute its biosolids production to beneficial use; and (2) an additional market for King County's biosolids may significantly reduce the cost of haul and application. Cost reduction could come from reduced haul cost and/or increased competition for a limited resource, namely King County's biosolids. For these reasons, a preliminary evaluation of the Centridry™ product's new market potential was evaluated by Norton-Arnold and Janeway, a public involvement and resource management consulting firm. A complete report of the new market assessment by Norton-Arnold and Janeway, Inc., is included in Appendix F. An overview of the results of the study is provided in the paragraphs below.

The preliminary survey conducted for King County's Centridry™ Demonstration Project consisted of telephone interviews with potential end-use customers. Two of these were composting companies currently experimenting with the Centridry™ product. Twenty-two were with topsoil companies identified from the U.S. West Yellow Pages. All were located in either King or Snohomish County. Telephone interviews were conducted in June 1998.

The research was based on the premise that composting companies would use Centridry™ to produce a Class A composted product, which would then be sold to topsoil companies. Topsoil companies would use this composted Centridry™ product in the blends and soil mixes they offer to their customers. Two sets of interview questions were used for the two categories of interviews.

Key interview findings indicate there is interest in a biosolids product that is drier than the products currently available (i.e., dewatered cake at 20 to 22 percent solids). Topsoil companies are familiar with biosolids products and feel that they perform well. Eight companies requested further information on Centridry™, and four of those expressed interest in working with King County on a pilot program for the product. This willingness is tempered, however, by interviewees' concern that there are negative public perceptions about the use of biosolids in general. Those interviewed are also concerned about odor control, dust, cost, and King County's ability to develop and maintain a long-term business relationship with them.

In addition to contacting potentially interested topsoil companies, Norton-Arnold and Janeway also contacted LRI and GroCo composters while they were testing the Centridry™ product in their operations. At the time of the interview, each company expressed optimism regarding the potential for Centridry™ to be utilized in their operations to produce a marketable product at lower cost.

TAB

4

SECTION 4

CENTRIDRY™ PRODUCT EVALUATION TESTS

As explained in the previous chapter, the results of the Centridry™ Demonstration indicated that the process is mechanically reliable and capable of dewatering and drying biosolids to fifty to sixty percent solids content, or more. However, serious questions were raised regarding the Centridry™ product quality, especially with respect to dust from the product, as well as odors generated from the product after several days of stockpiling. Product dusting issues were addressed by operational changes in the Centridry™ process. These are summarized in this section. The product odor issues were serious enough that King County elected to initiate a follow-up study focused specifically on the Centridry™ product odor. The goals of this follow-up study included the following:

1. Identify the causes of product odor.
2. Identify methods of controlling odors as product ages.
3. Evaluate composting of unamended Centridry™ product to Class A biosolids criteria.
4. Evaluate the feasibility of treating composting off-gases with biofiltration.
5. Evaluate the potential for beneficial reuse of composted product by end users.

The following paragraphs summarize the operational changes to control dusting and the activities and results associated with the follow-up product odor control study.

CONTROL OF PRODUCT DUSTING

Early in the operation of the Centridry™ Demonstration Project, and prior to resolving the operation problems with the system (see Section 3), the Centridry™ product produced was drier than anticipated (greater than 70 percent solids). This very dry product was observed to create dust, especially as it was being discharged from the cyclone conveyor into the truck. Some of this dried product was also taken to eastern Washington and applied to agricultural land where dusting was observed to be severe. Besides being a nuisance, the product dust was perceived by South Plant staff and agricultural field workers to be a health risk.

Based on these observations, the target product dryness was established at 55-60 percent solids, as the product with this dryness was not observed to create problematic dusting. As operational problems with the Centridry™ system were resolved, the ability to control product dryness to a target level improved, and problems with excessive dust appeared to be resolved.

PRODUCT ODOR CHARACTERISTICS AND IDENTIFICATION OF CONTROL METHODS

During the initial Centridry™ Demonstration Project, odors from the Centridry™ product, especially after a few days of stockpiling, were observed to be significant and unacceptable. It was judged that if left unabated, the product odors would preclude the use of Centridry™ product in any of King County's current biosolids beneficial-use markets, as well as any new markets. Thus, for Centridry™ to be a viable process for King County, product odors must be effectively controlled, if not substantially eliminated. To determine the feasibility of this goal, activities were initiated with the following objectives.

1. Characterize odors of fresh and aged product by chemical composition analysis;

2. Identify the mechanism for odor generation and evaluate potential odor control methods;

3. Provide conclusions regarding the feasibility of controlling odors from Centridry™ product.

To achieve these objectives, several activities were conducted jointly by King County and the Brown and Caldwell team. These activities and their results are described below.

Odor Characterization

As a first step in evaluating the Centridry™ product odor issues, and potential solutions, tests were conducted by King County in August 1999 to characterize the odors from the Centridry™ product under various conditions, and over time, and to compare these to odors from dewatered cake solids.

These initial tests would provide data that would be used to help brainstorm potential causes of the Centridry™ product odors, and develop potential odor control options.

The test procedure utilized 6-gallon buckets loaded with a known quantity of solid material (6.5 kilograms, wet weight basis). The buckets were fitted with gas-tight lids, with connections for collecting headspace gas samples, plus connections for aerating the sample, as appropriate.

Buckets were stored at 40 degrees C (104 degrees F) to simulate the autothermal conditions observed when Centridry™ product was stockpiled (in truck trailers or in piles). Four potential storage conditions were evaluated using the bucket test method:

1. Centridry™ product aerated;
2. Centridry™ product unaerated and unamended;
3. Centridry™ product unaerated and treated with lime (10 percent by weight);
4. Dewatered cake solids (control).

During the Demonstration Project, it was observed that product odors would become more severe over time. Therefore, bucket headspace gas samples were collected for analysis initially (t = 0 when the buckets were first filled), then at four days and fifteen days after the buckets were filled (t = 4, t = 15). Gas samples were analyzed for a wide range of compounds in order to assess what compounds were present in the off-gases, and how these compounds change over time. In addition, an odor panel was assembled to assess the qualitative characteristics and severity of the odors from each sample.

The results of these initial odor characterization tests are shown in Appendix D1. In general, these tests confirmed the observations of the Centridry™ Demonstration Project; specifically, in unaerated and unamended Centridry™ product samples, odor-producing compounds and observed odors (as determined by the odor panel) increase with time as the product remains in an unaerated state. Gas samples from the cake solids and the lime-treated Centridry™ product also showed increases in odor, and odorous compound concentrations, though the specific compounds and the intensity of the odors varied somewhat from the unaerated Centridry™ product. Significantly, the gas samples taken from the aerated Centridry™ product showed the least odors over time, both in terms of detection by the odor panel and measured concentrations of compounds.

Identify Mechanisms for Odor Generation and Methods for Controlling Odor

In order to determine the feasibility of controlling Centridry™ product odor to an acceptable level, the mechanism(s) that cause the odor must be identified, and techniques for controlling, or eliminating, these mechanisms must be confirmed. To this end, a one-day brainstorming workshop was convened on November 5, 1999, to achieve the following:

- Review data and observations to date regarding Centridry™ product odor;
- Develop hypotheses on the mechanisms that contribute to the odors;
- Develop testing plans to confirm or refute each hypothesis.

As shown below, the participants in the workshop encompassed a broad range of expertise in biosolids and microbiology, including King County staff, consultant team members, and outside experts.

Participant	Affiliation
Gary Newman	Brown and Caldwell, Project Manager
John Smyth	King County, Project Manager
Sue Hennig	King County, Biosolids Management Group
Jim Endres	King County, Environmental Lab
Larry Sasser	E&A Environmental Consultants (now Tetra Tech, Inc.)
Paul Rosenfeld, PhD	Bechtel (former University of Washington graduate student, researching biosolids odor issues)
Doug Newlands	King County, Biosolids Management Group
Raleigh Farlow	DMD, Inc., Chemist
David Stensel, PhD	University of Washington (biosolids processing)
David Stahl, PhD	Northwestern University (microbiologist)
Lisette Nenninger	King County, Centridry™ Product Lead Engineer
Katherine Bourbonais	King County, Environmental Lab
Bob Bucher	King County, Centridry™ Demonstration Project, Lead Engineer
Dick Finger	King County, West Division Manager

In general, the workshop was divided into 3 discussion sessions. First, the workshop participants reviewed the current knowledge of the Centridry™ product and its observed odors (i.e. data and observations from the Demonstration Project, distribution to beneficial-use sites, bucket tests). Next, the workshop focused on theories for the source of the Centridry™ product odor. Finally, the discussion turned to methods and procedures to test each of the most viable theories.

The workshop was successful in that several hypotheses regarding the source of odors were developed together with conceptual plans for testing the hypotheses.

The following represent the most viable hypotheses developed, and the conceptual test plan developed for each hypothesis:

Hypothesis 1

The objectionable odors when Centridry™ product is stored for several days are due to biological activity, rather than solely physical/chemical processes.

Test. Off-gas characteristics (odor intensity, chemical constituents) of sterilized product (gamma irradiation + sodium azide) would be compared to unsterilized product; both treatments would be stored under anaerobic conditions.

Interpretation. Higher levels of objectionable odors from the unsterilized product compared to the sterilized product would indicate that microorganisms contribute to odor generation. Similar odor levels between the treatments would indicate that odor emissions are attributable to the chemical and physical nature of the Centridry™ product.

Hypothesis 2

The objectionable odors when Centridry™ product is stored for several days are due to a lack of suitable electron acceptors (O_2, NO_3), allowing anaerobic and fermentative metabolism to occur. The products of anaerobic and fermentative metabolism are generally more odorous than those of aerobic respiration.

Tests. Off-gas characteristics of product stored under anaerobic conditions would be compared to product stored in an oxygen-rich environment. Plate counts of aerobic, anaerobic, and spore-forming bacteria would be conducted to characterize the microbial populations.

Interpretation. Lower levels of objectionable odors from the product stored under aerobic conditions would indicate that anaerobic and fermentative activity is responsible for odor generation. Bacterial counts should confirm this difference in microbial populations.

Hypothesis 3

The Centridry™ process selects for an odor-producing microbial population by inactivating populations that would normally compete with them.

Tests. Plate counts of aerobic, anaerobic, and spore-forming bacteria would be conducted on feed to the Centridry™ process and the product. Off-gas characteristics of product mixed with cake solids from the South Treatment Plant dewatering process would be compared to unamended Centridry™ product; both treatments would be stored with anaerobic headspace. Plate counts of aerobic, anaerobic, and spore-forming bacteria in the mixed and unamended treatments would be conducted to characterize the microbial populations.

Interpretation. Changes in the microbial population distribution from the Centridry™ feedstock to the product, particularly the fraction of spore-formers, would indicate microbial population selection by the Centridry™ process. Lower levels of objectionable odors from the product inoculated with cake solids would also indicate that odor production is attributable to selection for an odor-producing microbial population by the Centridry™ drying process. Bacterial counts in mixed and unamended product should confirm differences in microbial population distribution.

Follow-Up Tests

The bucket test technique, developed previously, was selected as the most practical test mechanism for this evaluation. The following were the specific bucket tests conducted in May 2000:

Bucket Test	Condition Evaluated
1	Centridry™ product stored with anaerobic headspace (intended to simulate storage conditions)
2	Centridry™ product sterilized by gamma-irradiation stored with anaerobic headspace
3	Centridry™ product stored with aerobic headspace (exogenous electron acceptor)
4	Centridry™ product mixed with cake solids (reinoculation of microorganisms)
5	Cake solids with anaerobic headspace

Over the two-week test period, gas samples were collected from the headspaces of the test buckets, and microbial data were collected from samples collected from the buckets. Test results are summarized in Appendix E.

Not all tests went as intended. For example, difficulty with the Draeger Tubes prevented collection of hydrogen sulfide data. Also, the irradiation of Centridry™ product did not kill all organisms. Consequently, the odors from a sterile product could not be investigated directly.

Nevertheless, significant and valuable data were collected, leading to important conclusions. The following summarizes the results of the tests relative to each hypothesis.

Hypothesis 1

Objectionable odors are caused by biological activity as opposed to solely physical/chemical conditions.

The test results showed that biological activity under anaerobic conditions resulted in the production and release of odor-causing compounds. This is evident by the increased concentration of odor compounds with time in the buckets under anaerobic conditions and the increase in microbial population concentrations. However, the test results were inconclusive about whether the Centridry™ process itself produces odors that are then released in storage. The reason this could not be shown is because the irradiated sludge was not sterilized. Thus, odors from biological activity versus odor release from the Centridry™ product were not conclusively determined.

Also, it was hypothesized that Centridry™ causes a transformation in the product cell structure (lysing), releasing readily biodegradable substrate that causes a spike in biological activity and hence rapid increase in odors. Results of Bucket 4 (Centridry™/cake solids mix) are consistent with this.

Hypothesis 2

Objectionable odors are the result of anaerobic fermentation (i.e. lack of sufficient electron acceptors—O2, NO3). Products of anaerobic fermentation are generally more odorous than products of aerobic metabolism.

Comparison of the aerobic Bucket 3 to the odor production for Buckets 1, 2, 4, and 5 show much higher odor production for sludge held under an anaerobic environment.

Hypothesis 3

The Centridry™ process selects for an odor-producing microbial population by inactivating populations that would normally compete with them.

The results from May 2000 bucket tests tend to disprove this. The cake solids provide the complete range of microbiota found in digested solids. The fact that this bucket produced some of the worst odors suggests that even if selection were occurring in the Centridry™ process, cake solids' microbiology only contributes to the odors, and does not help attenuate them.

Overall Conclusion

Centridry™ product stored aerobically (i.e. with sufficient electron acceptors) will be less odorous than product stored without sufficient electron acceptors (e.g. in a large unmixed pile), or product mixed with dewatered cake solids.

TAB

5

SECTION 5

ALTERNATIVES DEVELOPMENT

One of the objectives of the Centridry™ Demonstration Project was to acquire operating experience and develop operating data upon which to base an economic evaluation of full-scale implementation of Centridry™ at the South Plant. In order to evaluate Centridry™ for full-scale implementation, King County's current and potential future beneficial use practices must be evaluated in the context of the Centridry™ product and its characteristics. Likewise, plant-wide support systems must be evaluated in terms of the specific requirements of the Centridry™ process. Also, in order to understand the relative cost-effectiveness of full-scale implementation of Centridry™, it must be compared against a "baseline" biosolids dewatering process. For the South Plant, the baseline is replacing the existing belt filter presses with high speed centrifuges. Thus, four alternatives for future biosolids management at the South Plant have been developed: two alternatives based on full-scale implementation of Centridry™ (Centridry™ producing 55 percent solids dried product); one alternative based on a partial implementation of Centridry™; and one alternative based on complete conversion to conventional centrifuge dewatering (production of 25 percent solids dewatered cake).

Each of these alternatives has been developed based on common assumptions of solids production for South Plant, design criteria and reliability standards for South Plant, and the operating and maintenance philosophy at South Plant. By necessity, each alternative differs in terms of the ultimate product produced and the performance of individual systems within each alternative. The following paragraphs describe each alternative, the sizing criteria for each alternative's life cycle cost evaluation for operation into the future, and assumptions with respect to performance of individual alternative components. Alternative development presented in this section forms the basis for the evaluation of alternatives presented in Section 6.

BASIS OF ALTERNATIVE DEVELOPMENT

Three parameters establish the fundamental basis of alternative development: (1) the "planning period" over which each alternative will be evaluated; (2) future solids production estimates over that planning period; and (3) the design criteria to be applied to each alternative. Each of these is discussed in the paragraphs below.

Planning Period for Alternative Evaluation

In meetings with King County Department of Natural Resources (KCDNR) representatives, it was agreed that a 15-year evaluation period would be utilized for this study.[5-1] This period was selected because it was believed to be consistent with the observed life expectancy of large and complex mechanical equipment, in this case centrifuge equipment. Thus, all capital would be amortized over 15 years; likewise, the present worth of annual operations and maintenance costs would be evaluated over a 15-year period.

In addition, the evaluation will be based on the 15-year period extending from 2005 (first full year of operation) through 2019. This assumes the existing belt presses, which went into operation in 1988, will be replaced in years 2003-2004, which is consistent with the assumption above regarding a 15-year life expectancy for this type of equipment. Also, it is estimated that any major capital improvement in dewatering at South Plant would take approximately four years to implement (design through construction and startup).

Future Solids Production Estimates

Digested solids production estimates for the South Plant were provided by King County, and are summarized in Table 5-1. These estimates assume that a third treatment plant is added to the King County wastewater treatment system and brought on line in 2009. Thus, for this evaluation, solids production rises through the year 2009, then drops. Therefore, the "design year" for this evaluation is 2009. For digested solids production, these projections assume that digestion efficiency, in terms of volatile solids reduction, remains at the high levels historically achieved at South Plant.

Table 5-1. Estimated Future South Plant Solids Production (from King County[5-2])

Year	Average digested solids to dewatering, lb/day dry solids	Average dewatered and/or dried solids to beneficial use, lb/day dry solids (a)
2005	91,318	86,752
2006	92,417	87,796
2007	93,516	88,840
2008	94,615	89,884
2009	95,715 (b)	90,929
2010	92,087	87,483
2011	93,275	88,611
2012	94,463	89,740
2013	95,650	90,868
2014	95,171	90,412
2015	94,691	89,956
2016	94,212	89,501
2017	93,732	89,045
2018	93,253	88,590
2019	92,774	88,135

(a) Dewatered and/or dried biosolids assumed.
(b) Design year for sizing centrifuge dewatering and Centridry™ drying systems.

Solids Stabilization

For this evaluation, all alternatives assume that raw solids produced at South Plant will be stabilized to Class B solids through high-rate mesophilic anaerobic digestion in the existing four 100-foot diameter digesters (plus the blending/storage tank). No changes to the digestion process are anticipated for purposes of this evaluation. Consequently, digestion performance is assumed to remain similar to the 55-60 percent volatile solids reduction currently achieved. Likewise, the characteristics of the digested solids will also remain similar to current characteristics (total solids in digested sludge typically range between 2.8 and 3.2 percent; total volatile solids typically range between 63 and 68 percent volatile solids).

Design Criteria

Historically, critical unit processes at South Plant have been designed based on the criterion that the facilities must have the capacity to process the maximum anticipated loadings while one unit is out of service. Alternatives for this evaluation have been developed consistent with this criterion.

The maximum loading condition assumed for this evaluation is maximum week during the design year of 2009. Maximum week was selected rather than maximum day, to account for South Plant's on-line digested solids storage capacity in the blending/storage tank and in floating cover travel in the digesters themselves. Recent solids production peaking factor evaluations by King County yield a maximum week peaking factor of 1.43, and a maximum week digested solids production of 137,000 dry pounds per day to dewatering in the design year.[5-3]

Average and peak digested solids production, in terms of both dry solids and liquid flow rate, are shown in Table 5-2.

Table 5-2. Summary of Peak Digested Solids Production in Design Year (2009)

Condition	Digested solids to dewatering, lb/day	Liquid flow rate from digesters, gpm (b)
Average annual	95,715	280
Peak 3-week (a)	125,387	366
Peak week (a)	136,872	400
Peak day (a)	156,015	456

(a) Peaking factor applied to average annual solids production, and includes additional base solids production observed during winter months.
(b) Liquid flows assume 2.85 percent solids in digested sludge.

Each alternative is sized to accommodate the design year maximum week solids production with some percentage of processing units out of service. As explained above, this is consistent with the basic design criteria at South Plant, including solids processing. For example, dissolved air flotation thickening is designed to accommodate maximum loads with one 65-foot diameter thickener out of service (one thickener represents 20.5 percent of total installed capacity); likewise, the current digestion process is designed to accommodate maximum loads with one digester (25 percent of total capacity) out of service. Based on this, each dewatering alternative will be developed on criteria of including at least 20 percent standby capacity during design year peak week solids production.

Finally, each alternative will be developed on the basis of 24-hour per day, 7-day per week operation. This is consistent with the current dewatering process operation at South Plant.

Centridry™ Product Odor Control

As explained in Section 4, evaluation of the Centridry™ product in a series of bucket tests demonstrated that providing aeration during storage would dramatically reduce the release of odorous compounds. The mechanism for this reduction in odors is believed to be associated with maintenance of ambient temperatures and / or aerobic conditions. Delivery of low odor Centridry™ product would therefore require aeration from the time of production to delivery at the utilization site. Aeration during storage and transport can be provided with modification of the long haul biosolids truck trailers.

The air requirement for the trailer modification is based on experience during the bin testing of the composting product (see Appendix C-1). An aeration rate of 250 scfm per trailer or 500 cfm per combination would be able to maintain the desired conditions. A fan with a 3 hp motor can provide this air flow with 12 inches of water column pressure. The power source for the fan could be either the tractor engine or an independent gas or diesel driven engine. A small dedicated engine is the preferred power source because it provides air to product in the trailer without running the tractor engine. Thermo-King and Carrier manufacture refrigeration units for long haul trailers that use the small dedicated engine approach.

Use of commercially available truck mounted refrigeration units for aeration was evaluated. These units are not suitable because of the configuration of the existing truck fleet. It appears likely that custom fabricated fan units modeled after the commercial refrigeration units would be required. The estimated cost of these fabricated units based on the cost of the commercial units is $20,000 per truck. This would include a small gas or diesel engine, a fan, piping to the trailers, and a carbon canister for odor control. In addition, the trailer would need to be modified by adding a plenum to uniformly pull air through the material. The fan would then discharge through the carbon canister. Modification of the trailer is estimated at $10,000 per tractor and trailer combination. Thus, the total cost of modifying the biosolids truck trailers is approximately $30,000 per unit. It is estimated that the annual operation and maintenance cost for operating these aeration units would be less than $2,500 per year. The trailer aeration system design is based on information developed in pilot testing, and the system would be new and innovative. It is therefore recommended that a demonstration unit be installed on one trailer combination and tested as the first phase of implementation. Refinements to the system, with follow-on demonstration testing, may be required to develop a fully functional and reliable system.

DESCRIPTION OF ALTERNATIVES

Four primary alternatives for biosolids processing have been developed for evaluation. All alternatives include replacing the existing belt presses. To the extent practical, each alternative is based on common assumptions in order to yield an "apples-to-apples" comparison. However, each alternative also reflects a different philosophy for managing biosolids from the South Plant. Alternatives are as follows:

Alternative 0: All centrifuges producing Class B dewatered cake at 25 percent solids

Alternative 1: All Centridry™, producing Class B dried product at 55 percent solids

Alternative 2: All Centridry™, followed by on-site composting, producing Class A dried product at 55 percent solids

Alternative 3: Dewatering using centrifuges, plus drying using Centridry™, with approximately 2/3 production as Class B dewatered cake at 25 percent solids, and 1/3 production as Class B dried product at 55 percent solids

In developing these alternatives it is recognized that the cost-effectiveness of each alternative would be heavily influenced by the end use of the product. Therefore, sub-alternatives have been developed for each of the Centridry™ alternatives (1, 2, and 3), which reflect various biosolids beneficial-use options for the Centridry™ product. For Class B Centridry™ product (Alternatives 1 and 3), beneficial-use alternatives are as follows:

Sub-alternative A: 100 percent to eastern Washington agriculture.

Sub-alternative B: 50 percent to eastern Washington agriculture; 50 percent to contract composting.

Sub-alternative C: 80 percent to eastern Washington agriculture, 20 percent to silviculture.

For Class A composted Centridry™ product (Alternative 2), beneficial use alternatives are as follows:

Sub-alternative D: King County pays contractor to haul and distribute for beneficial use.

Sub-alternative E: Pick-up product by user, no cost to King County.

Sub-alternative F: Pick-up product by user, at a purchase price; i.e. revenue to King County.

The paragraphs below summarize the features of each alternative and the biosolids management philosophy reflected in each. Table 5-3 provides a summary of each alternative; the alternatives are depicted schematically on Figures 5-1, 5-2, 5-3, and 5-4. For Alternatives 1, 2, and 3, specific features of the proposed Centridry™ systems are as provided by Baker Process; see letter of October 3, 2001, from Brian Lent, Bird Machine Company, included as Appendix J.

Table 5-3. Summary of Alternatives

Component	Alternative 0	Alternative 1	Alternative 2	Alternative 3
Digester capacity	Existing Digesters 1-4, HRT 20+ days Class B	Existing Digesters 1-4, HRT 20+ days Class B	Existing Digesters 1-4, HRT 20+ days Class B	Existing Digesters 1-4 HRT 20+ days Class B
Dewatering/drying	3 new high solids centrifuges rated at 200 gpm (3,000 lb/hr) each	3 new CD 3074 Centridry™ trains, rated at 3,000 lb/hr each (a) (b)	3 new CD 3074 Centridry™ trains, rated at 3,000 lb/hr each (a) (b)	• 2 new high solids centrifuges rated at 200 gpm (3,000 lb/hr) each • 1 new CD 3074 Centridry™ train, rated at 3,000 lb/hr (a) (b)
Units operational/ backup for maximum week, design year	• 2 duty • 1 standby	• 2 duty • 1 standby (Note Centridry™ units convertible to dewatering service)	• 2 duty • 1 standby (Note Centridry™ units convertible to dewatering service)	• 2 centrifuges--duty • 1 or 0 Centridry™--standby • 1 or 0 centrifuge--standby (Note Centridry™ units convertible to dewatering service)
Support equipment	• 3 new centrifuge feed pumps • 3 new polymer feed pumps • 3 classifying conveyors • Dewatered cake conveyors • Overhead lifting device	• 3 new Centridry™ feed pumps • 3 new polymer pumps • 3 new hot air generators with digester gas feed (b) • 3 new gas booster blowers • 3 cyclone air/product separators (b) • 3 recycle hot air fans (b) • 3 waste hot air fans (b) • Dried product/dewatered cake conveyors • Overhead lifting device	• 3 new Centridry™ feed pumps • 3 new polymer pumps • 3 new hot air generators with digester gas feed (b) • 3 new gas booster blowers • 3 cyclone air/product separators (b) • 3 recycle hot air fans (b) • 3 waste hot air fans (b) • Dried product/dewatered cake conveyors • Overhead lifting device	• 3 new centrifuge/ Centridry™ feed pumps • 3 new polymer pumps • 1 new hot air generator (b) • 1 new gas booster blower • 1 cyclone air/product separator (b) • 1 recycle hot air fan (b) • 1 waste hot air fan (b) • 3 new classifying conveyors • Dewatered/dried cake conveyors • Overhead lifting device
Polymer storage and conditioning	• Retain existing liquid and dry storage and mixing facilities (c)	• Retain existing liquid and dry storage and mixing facilities (c)	• Retain existing liquid and dry storage and mixing facilities (c)	• Retain existing liquid and dry storage and mixing facilities (c)

Table 5-3. Summary of Alternatives

Component	Alternative 0	Alternative 1	Alternative 2	Alternative 3
Dewatering Building modifications	• Increase structural load-bearing capacity for centrifuges	• Increase structural load-bearing capacity for Centridry™ • Add architectural enclosure for cyclones	• Increase structural load-bearing capacity for Centridry™ • Add architectural enclosure for cyclones	• Increase structural load-bearing capacity for centrifugal Centridry™ • Add architectural enclosure for cyclone
Electrical	• Replace existing 750 kVA transformers with new 1,000 kVA transformers • Replace cables between transformers and Dewatering Building	• Provide new 13 kV feeder from solids area MCC • Replace existing 750 kVA transformers with new 2,000 kVA transformers • Provide new cabling between transformers and Dewatering Building • Provide new MCC Room	• Provide new 13 kV feeder from plant's Main Switchgear Building • Replace existing 750 kVA transformers with new 2,000 kVA transformers • Provide new cabling between transformers and Dewatering Building • Provide new MCC Room	• Provide new 13 kV feeder from Solids Area MCC • Replace existing 750 kVA transformers with new 2,000 kVA transformers • Provide new cabling between transformers and Dewatering Building • Provide new MCC Room

Odor control for dewatering/drying	• Two-stage odor control:
	  • Water-based scrubbing (d)
	  • Activated carbon (e)
		• One-stage odor control-activated carbon (e)
		• Venturi and packed bed (water) scrubber; one per Centridry™ system (b)
			• One-stage odor control-activated carbon (e)
			• Venturi and packed bed (water) scrubber; one per Centridry™ system (b)
				• Two-stage odor control:
				  • Water-based scrubbing (d)
				  • Activated carbon (e)
				• Venturi and packed bed (water) scrubber; one per Centridry™ system (b)

Dewatered/dried product characteristics leaving Dewatering Building	• 25 percent solids cake • Class B	• 55 percent total solids Centridry™ product • Class B	• 55-60 percent total solids Centridry™ product • Class B	• 25 percent solids cake • 55 percent total solids Centridry™ product • Class B
Further product processing	None, Class B cake	• Aeration in truck trailers to reduce odor potential • Class B	• Aerated static pile com-posting, with biofiltration for odor control • Class A product	• No further processing for dewatered cake • Aeration of Centridry™ product in truck trailers to reduce odor potential • Class B (both products)

Table 5-3. Summary of Alternatives

Component	Alternative 0	Alternative 1	Alternative 2	Alternative 3
Target biosolids markets	Current users of Class B dewatered cake, including commercial composters	1A: 100 percent to agricultural use 1B: 50 percent to agriculture, 50 percent to contract composting 1C: 80 percent to agriculture, 20 percent to silviculture	2D: $2/wet ton tipping fee, plus haul, paid by King County 2E: Pick-up by user at no cost to King County 2F: Pick-up by user and purchase at $5/wet ton	• Dewatered cake to current users of Class B product • Centridry™ product: 3A: 100 percent to agricultural use 3B: 50 percent to agri-culture, 50 percent to contract composting 3C: 80 percent to agri-culture, 20 percent to silviculture

(a) Centridry™ systems convertible to dewatering and vice versa for biosolids flexibility.
(b) Included in Centridry™ system scope of supply.
(c) Capacity of existing bulk polymer storage and mixing facilities to meet centrifuge and/or Centridry™ demands must be verified.
(d) Existing packed bed scrubber. Feasibility of effective odor control using water (effluent) only needs to be verified.
(e) Existing activated carbon tower.

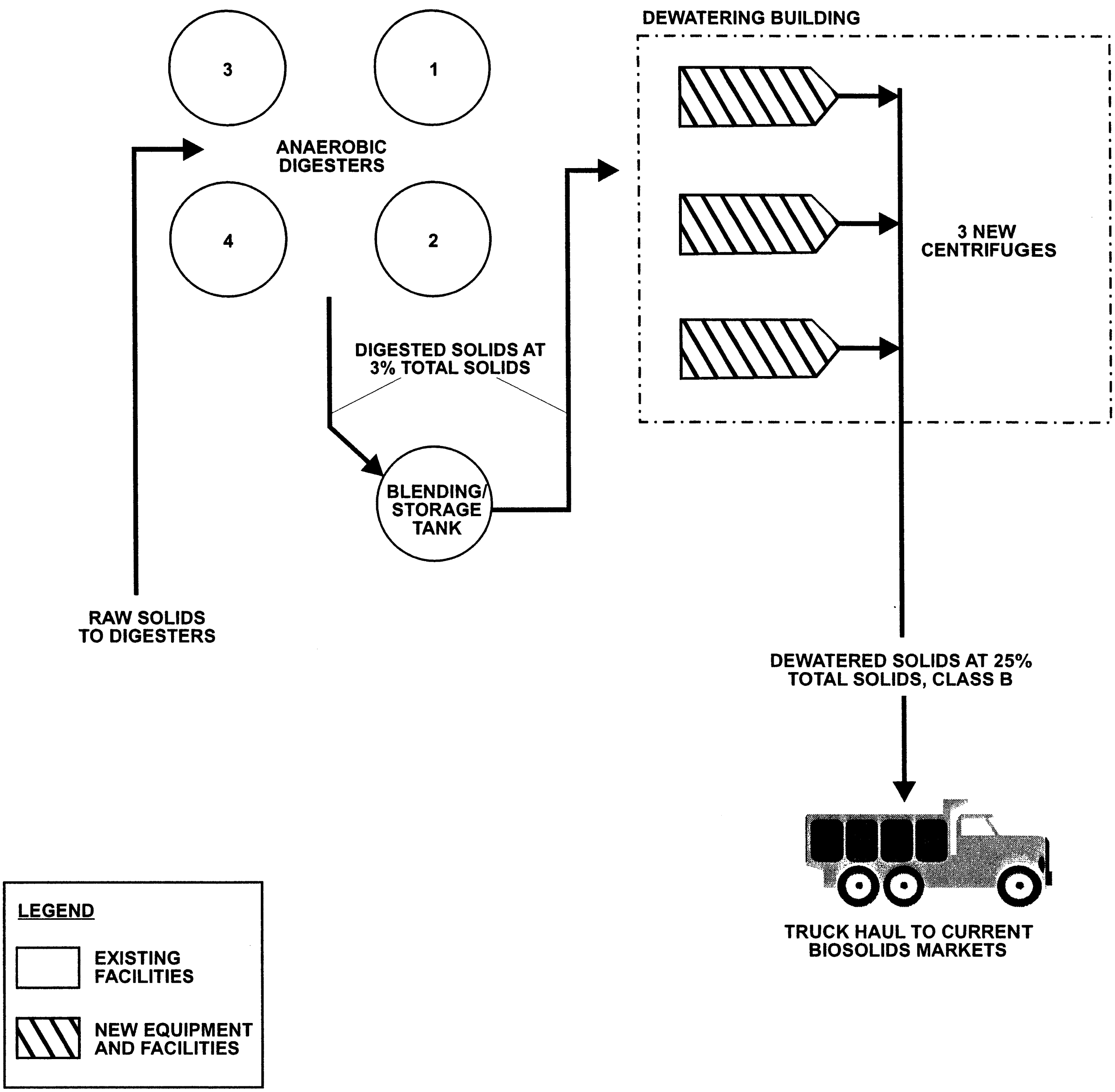

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Figure 5-1. Schematic of Alternative 0, Replace Belt Filter Presses with Centrifuges

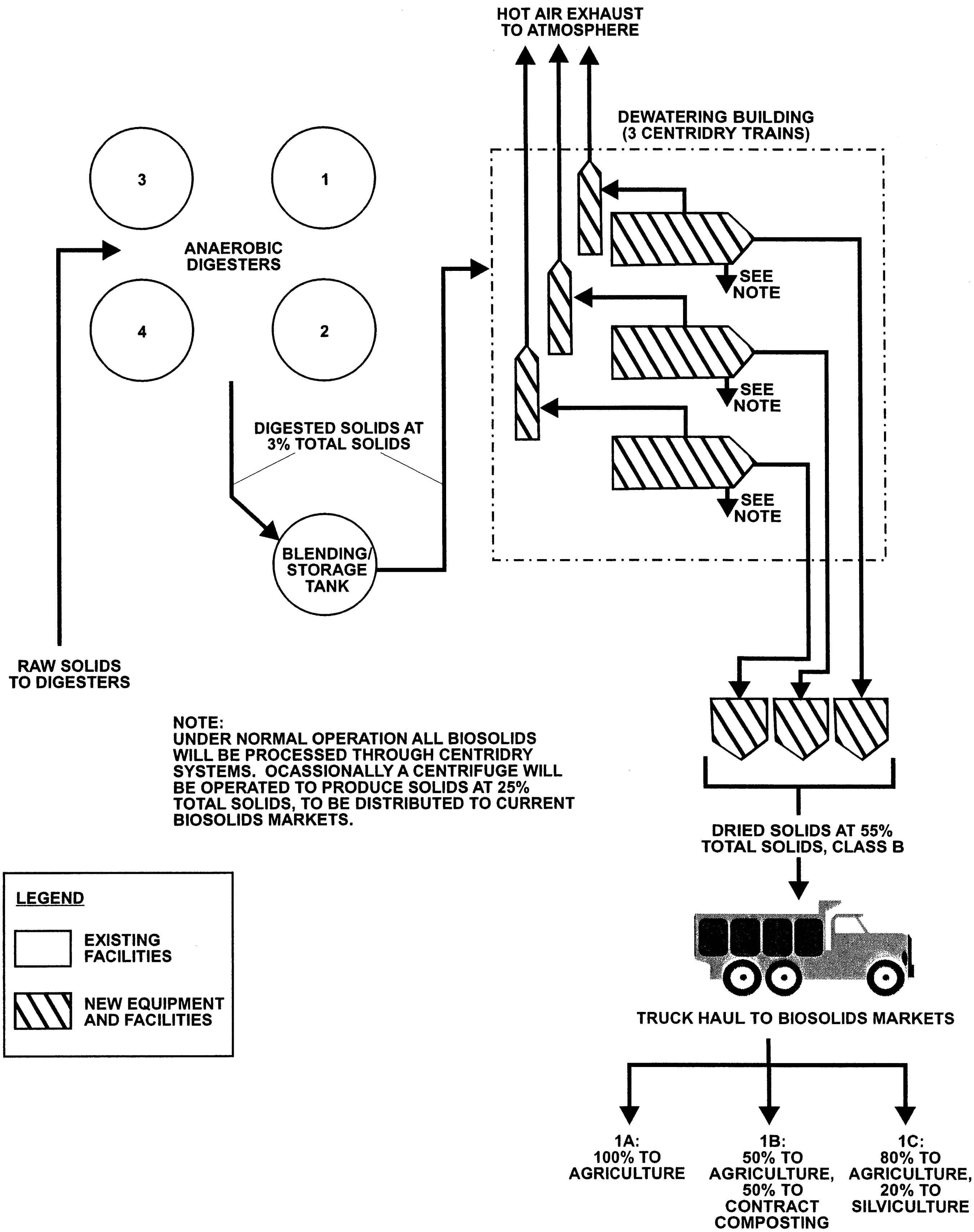

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Figure 5-2. Schematic of Alternative 1, Centridry Drying

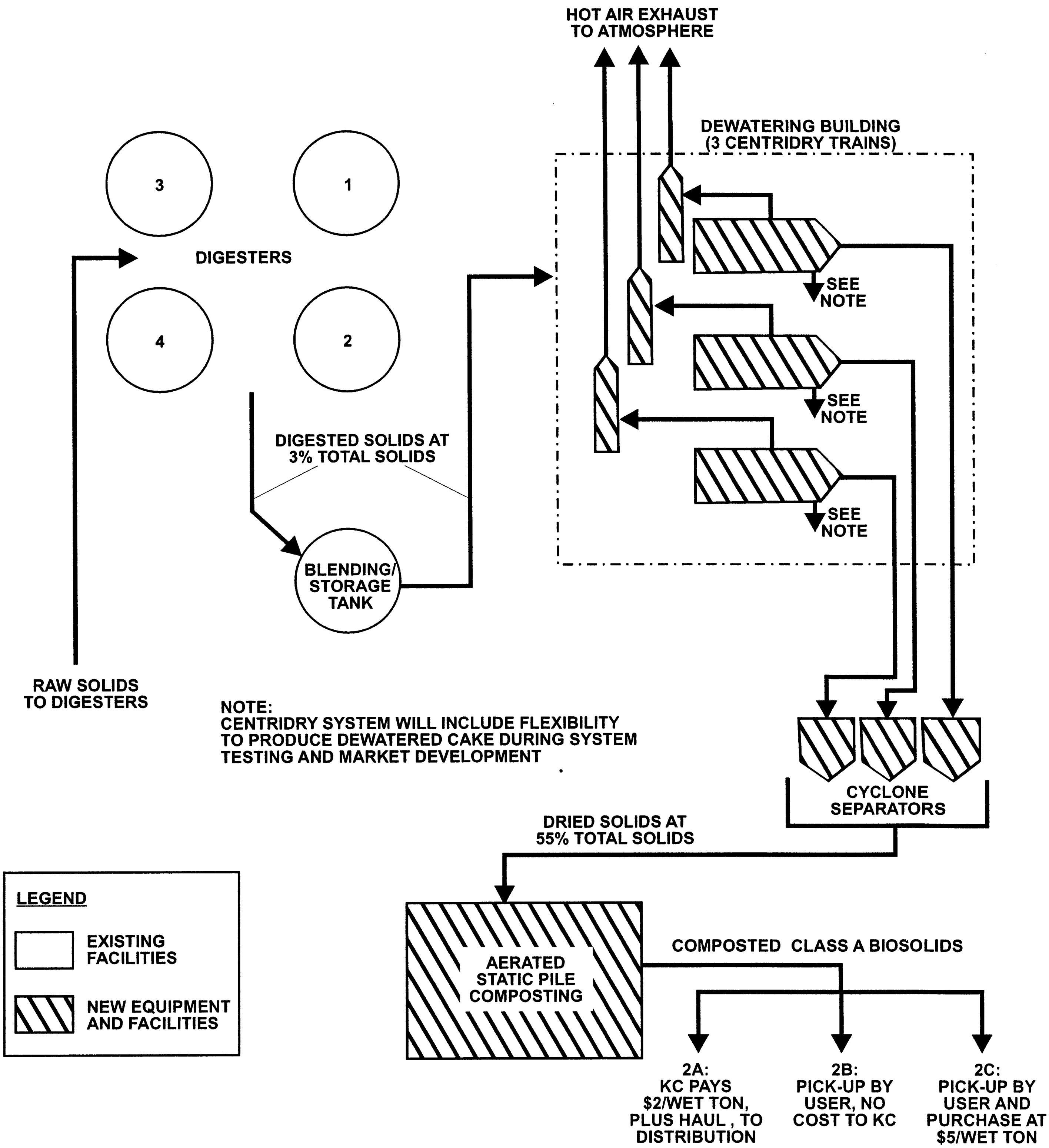

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Figure 5-3. Schematic of Alternative 2,
Centridry Dewatering/Drying Followed by Composting

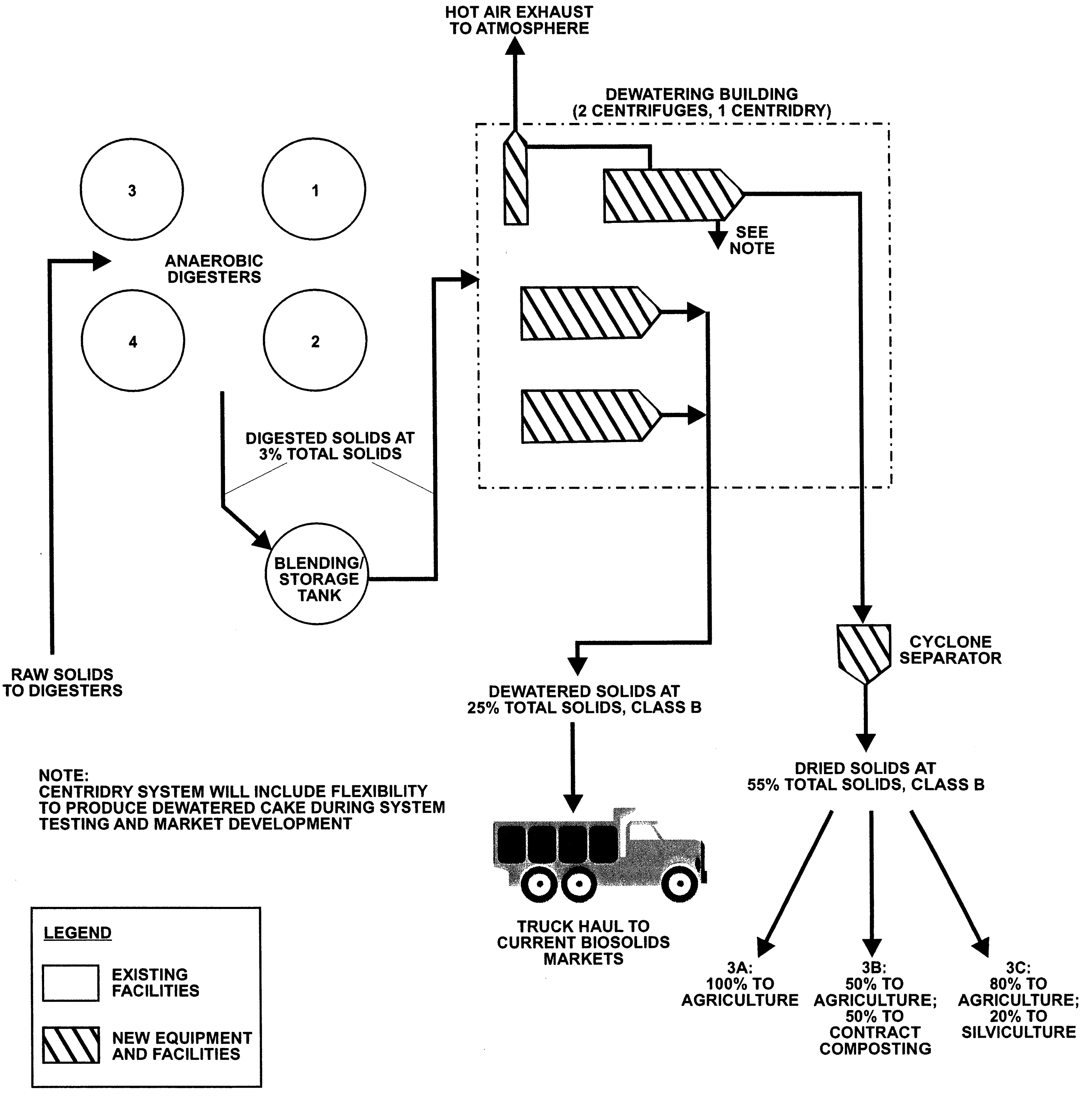

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**Figure 5-4. Schematic of Alternative 3,
Centrifuge Dewatering and Centridry Drying**

Alternative 0: All Centrifuge Dewatering, Producing Class B Dewatered Cake at 25 Percent Solids

As mentioned previously, the existing belt presses at the South Plant are approaching the end of their useful life. Consequently, King County has decided to proceed with replacing the belt presses with high solids centrifuges. Preliminary design for this replacement is proceeding concurrently with the completion of this Centridry™ Demonstration Project report.

It is anticipated that three high solids centrifuges will be required to meet the design requirements for the South Plant. Each will be nominally rated for 200 gallons per minute (gpm) liquid throughput, and 3,000 pounds per hour solids throughput (assuming three percent total solids concentration in the liquid digested sludge).

To avoid awkward construction sequencing impacts, two of the three new centrifuges will be located in a new extension of the Dewatering Building. This will allow these new centrifuges to be installed and commissioned prior to demolishing the existing belt presses. The truck loading bay will also be extended to facilitate the longer trucks currently used by King County. Other modifications to the Dewatering Building to accommodate centrifuges include new centrifuge feed pumps, new polymer feed pumps (existing polymer storage, dilution, and mixing facilities are assumed to be adequate for the centrifuges, but this must be verified during detailed design), new digested sludge conveyers, new overhead crane for maintenance, and miscellaneous structural, electrical (includes upsized transformers and cables serving the building), and control modifications to support this new process. It is anticipated that some structural modifications to the existing Dewatering Building will be required to accommodate the new centrifuges. Odor control will continue to be achieved via the two-stage process currently serving the Dewatering Building: chemical scrubbers followed by activated carbon. The modified Dewatering Building, including the new centrifuges, is depicted in Figure 5-5.

The centrifuges are expected to produce dewatered cake with 25 percent total solids. This is based on the results of pilot tests conducted by three centrifuge suppliers, Andritz, Alpha-Laval, and Westfalia, during the summer of 2001. This is substantially "drier" than the current belt press dewatered cake, which typically ranges between 17 and 19 percent total solids. Though higher in solids content, the centrifuge dewatered cake is expected to be similar to the belt press cake in terms of consistency, odor, and general appearance. Consequently, it is expected that the centrifuge dewatered cake will be compatible with the same beneficial-use markets as the belt press dewatered cake. These include agriculture land application in eastern Washington (wheat and hops), silviculture land application in the Cascade mountains, and composting to Class A and subsequent marketing by a commercial contractor, GroCo. Currently, biosolids from the South Plant are sent to these beneficial uses in the following approximate percentages:

Market	Current percent of South Plant biosolids production[5-4]
Eastern Washington agriculture	49
Silviculture	44
Composting	7

Recent discussions with King County Biosolids Management Group staff indicate that after the year 2005, more biosolids will go to agricultural use, rather than silviculture. The expected percentage distribution for South Plant biosolids following 2005 is shown below:

Market	Projected South Plant biosolids production after 2005[5-4]
Eastern Washington agriculture	81
Silviculture	12
Composting	7

This alternative assumes that the post-2005 percentages stay the same over the planning period. Haul and application costs for centrifuge dewatered cake will be based on the wet ton unit costs currently seen by King County. Existing biosolids haul trucks would be used for hauling biosolids to beneficial-use sites.

Alternative 1: All Centridry™ Dewatering Producing Class B Dried Product at 55 Percent Solids

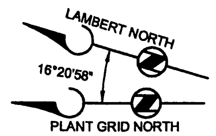
In this alternative, existing belt presses will be replaced with three complete Centridry™ systems, including centrifuge, hot air generator, cyclone air/product separator with rotary valve and conveyor, recirculation fan, Venturi scrubber with fan and water pump, waste air discharge stack, and control panel. In addition, each Centridry™ train will be designed to be converted to conventional dewatering if needed.

The three Centridry™ systems will be capable of meeting the design year maximum week digested sludge production rate. Under average conditions, only two Centridry™ trains will be required to be operated. If, during a period of solids production higher than average, and one Centridry™ system is not available, then one of the two remaining Centridry™ systems can be temporarily converted to conventional dewatering. It is assumed that a dewatering centrifuge will have more capacity than a Centridry™ system. This is because a Centridry™ centrifuge must optimize dewatering in order for the drying component of the process to work. A centrifuge, on the other hand, does not have this limitation. Therefore, capacity may be increased, at the expense of wetter cake solids.

Related support systems were evaluated as part of this alternative analysis:

- All the new Centridry™ and centrifuge equipment would be located within the existing Dewatering Building structure, with the exception of the cyclones, which would be located immediately outside the south wall of the truck loading bay. Architectural treatment would be provided to screen the cyclones from 7th Avenue and Oaksdale Avenue.

- The Dewatering Building structure was evaluated based on loads (static and dynamic) imposed by the centrifuges and related Centridry™ equipment (as provided by Humboldt). Based on a very brief evaluation, it is concluded that some



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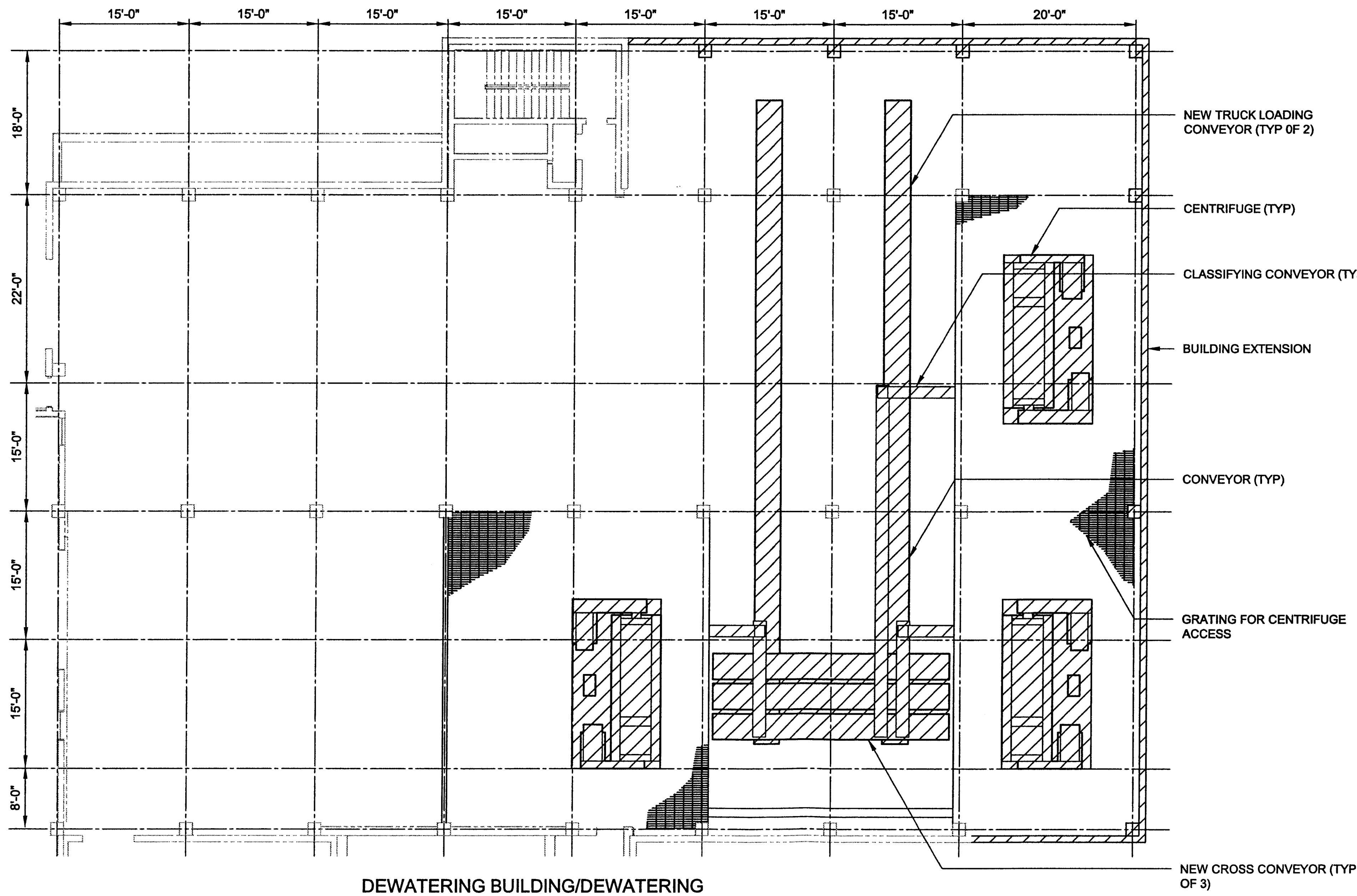
NOTES:

1. TRUCK FUELING AND WASH STATION RELOCATED TO THE SOUTH TO MAKE ROOM FOR BUILDING EXTENSIONS.
2. SIZE AND RELATIVE CONFIGURATION OF CENTRIFUGE, BASED ON ALPHA-LAVAL DS706.

LEGEND:

- EXISTING FACILITIES
- NEW FACILITIES
- NEW EQUIPMENT, FACILITIES



DEWATERING BUILDING/DEWATERING PLAN

Figure 5-5
Alternative 0
Centrifuge Equipment Layout

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significant structural modifications will be required in order to accommodate the projected loads, and to comply with recent revisions of the Uniform Building Code. (See Appendix G).

- Existing polymer storage, dilution, and mixing systems would be retained; new polymer feed pumps would be provided with each Centridry™/centrifuge dewatering train.

- New digested solids feed pumps would be provided with each new Centridry™ centrifuge train.

- A new, and higher capacity, electrical power service would be required to serve the Centridry™ and centrifuge systems. This would include a new motor control center and switchgear room.

- Exhaust ventilation air from the Dewatering Building would be routed through the existing carbon tower for odor control. The existing packed bed chemical scrubbers will not be utilized; this is based on the relatively low level of odors observed from the Demonstration Project operation with Venturi and packed bed scrubbers provided with the Centridry™ system. It is anticipated that adequate odor control can be achieved by carbon adsorption by itself.

- Each of the three Centridry™ systems would be provided with the flexibility to produce dewatered cake (25 percent solids), but this feature would only be used for process optimization of the Centridry™ product.

- Digester gas, with natural gas or propane backup, must be conveyed to the Dewatering Building to provide fuel for the hot gas generators in each drying train.

One possible layout of Centridry™ system components within the Dewatering Building is depicted in Figure 5-6.

Obviously, the Centridry™ product has different characteristics than dewatered cake. Consequently, the disposition of this product within King County's beneficial-use programs will likely vary from dewatered cake. At this time, without more experience in utilizing Centridry™ product at beneficial-use sites, it is not possible to predict with accuracy what the mix of beneficial uses for this product might be. Therefore, a range of beneficial-use options has been developed as sub-alternatives. These are described below.

Sub-alternative 1A: 100 Percent to Eastern Washington Agriculture. This sub-alternative assumes that all Centridry™ product will be hauled to current, or possibly new, agricultural beneficial-use sites in eastern Washington. To avoid creating nuisance odors, Centridry™ product will be hauled in existing biosolids trucks, modified to provide aeration of the product throughout its trip to the beneficial-use site, as explained above.

Sub-alternative 1B: 50 Percent to Eastern Washington Agriculture; 50 Percent to Contract Composting. This alternative reflects the potential attractiveness of the Centridry™

product in the contract composting operation. Splitting the production between eastern Washington agriculture and composting reflects the need and/or desire to maintain markets for biosolids with current agricultural users. Again, Centridry™ product would be transported in existing biosolids trucks outfitted with on-board aeration.

Sub-alternative 1C: 80 Percent to Eastern Washington Agriculture; 20 Percent to Silviculture. This alternative reflects the potential for using Centridry™ product in silviculture applications. Experience with Centridry™ product in this application demonstrated some problems with applying Centridry™ product to forest land. Therefore, only 20 percent of the South Plant's production has been allocated to this market. Centridry™ product would be hauled to either application site in modified biosolids trucks, similar to Sub-alternatives A and B.

Alternative 2: All Centridry™ Followed by Composting, Providing Class A Dried Product at 55 Percent Solids

From a dewatering/drying perspective, this alternative is identical to Alternative 1—the existing belt presses will be replaced with three Centridry™ trains. The proposed layout within the Dewatering Building is also identical, as shown in Figure 5-6. The significant difference between this alternative and Alternative 1 is in the further treatment of the Centridry™ product, and the resulting beneficial-use markets. Specifically, all Centridry™ would be composted to Class A standards. For purposes of developing this alternative, it is assumed that the composting facility would be located on the South Plant Site.

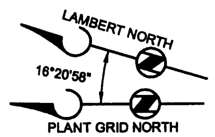
The composting system proposed for this evaluation is described in Appendix C-1. The key features of the system are described below.

- Compost process: Aerated static pile composting of straight Centridry™ product, without bulking agent. The composting facility has been sized to compost the Centridry™ product for 21 days. This is long enough to comply with pathogen and vector attraction reduction requirements. The product will be more stable after composting but will not be a mature compost product. The intended users of this material are topsoil and organic product manufacturers that will blend the Centridry™ compost with other materials to produce high value products. It is expected that the composted Centridry™ product would be distributed through contractors that have been competitively selected by the County.

- Three-acre composting facility to be located on the South Plant site (see Figure 5-7).

- Composting facility would be fully enclosed for odor control.

- Foul air from within the building would be routed through a two-stage odor control facility. The first stage would be packed bed chemical scrubbers (existing packed bed scrubbers at the Dewatering Building would be relocated to serve the composting facility); the second stage would be a biofilter.



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NOTES:

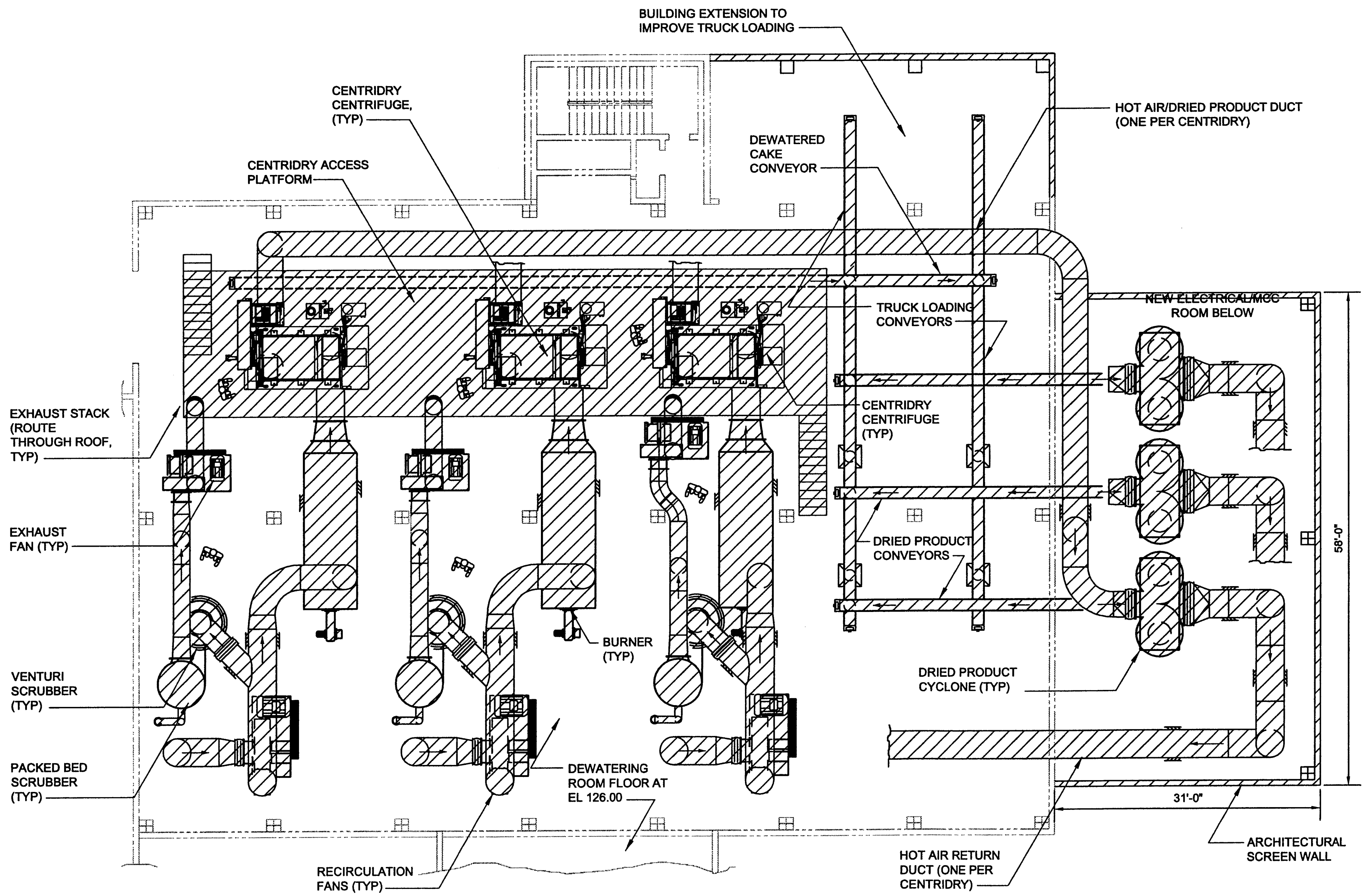
1. TRUCK FUELING AND WASH STATION RELOCATED TO THE SOUTH TO MAKE ROOM FOR CYCLONES.
2. SIZE AND RELATIVE CONFIGURATION OF CENTRIDRY CENTRIFUGE, BURNER, FANS, SCRUBBERS, CYCLONES, EXHAUST STACK, AND CONNECTING DUCTWORK PROVIDED BY HUMBOLDT (NOW BAKER PROCESS).
3. SEE FIGURE 5-5 FOR EXISTING BUILDING DIMENSIONS.

LEGEND:

EXISTING FACILITIES

NEW FACILITIES

NEW EQUIPMENT, FACILITIES



DEWATERING BUILDING/DEWATERING PLAN

Figure 5-6
Alternatives 1 and 2
Centridry™ Equipment Layout

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- Centridry™ product would be conveyed to the compost facility via truck and trailer. Existing biosolids trucks would be used; however, unlike Alternative 1, these trucks would not require retrofitting with on-board aeration because the transport time would be very short.

- The enclosed composting facility would be provided with a dust control system.

The composting facilities described above and in Appendix C are presented only for purposes of establishing a basis for cost estimating and evaluation. If King County were to proceed with full-scale implementation of Centridry™ product composting, additional study would be required in order to determine the optimum composting process, facility location, odor control system, dust control system, conveyance of 55 percent product to composting, etc.

Figure 5-7 shows the site plan for Alternative 2, including a proposed location of the enclosed aerated static pile composting facility on the South Plant site. The site shown for the composting facility was selected due to the availability of open space, and its central location within the South Plant site, which allows for some further mitigation of remaining odors released after treatment via the associated odor control facilities.

Because the resulting Centridry™ product will be Class A, potentially new markets and approaches to beneficial-use may be appropriate. A range of beneficial-use approaches has been developed to reflect the potential range of costs associated with this alternatives. These are presented below.

Sub-alternative 2D: King County Pays a Contractor to Haul Class A composted Centridry™ Product to Beneficial Use. In this sub-alternative, King County has already incurred the cost to convert Class B Centridry™ product to Class A via composting. King County would then pay an independent contractor to haul and distribute the product to beneficial-use sites that would presumably benefit from a Class A product (examples: top soil manufacturers, potting soil manufacturers, landscapers, etc). Further, it is assumed that the new Class A product markets would be located within King, Snohomish, or Pierce County, thereby reducing the haul costs compared to hauling to eastern Washington. An arbitrary unit cost of $2 per wet ton of composed product has been established for this alternative, to cover contractor costs to haul and distribute the product. It is assumed that the contractor also receives any revenue from the sale of the product; i.e. the contractor "owns" the Class A product once King County completes the composting process.

Sub-alternative 2E: Pickup Class A Composted Centridry™ Product by Users; No Cost to King County. This alternative assumes that once the Centridry™ product is composted to Class A standards, the demand for the product will be such that users will be inclined to pick up the product and haul it to their own beneficial-use sites. King County would incur no cost after composting, nor would it receive any revenue. The final Class A product would be available at the South Plant site, or wherever the composting facility is located, free of charge.

Sub-alternative 2F: Pickup by Users at a Purchase Price. This sub-alternative is identical to Sub-alternative E, except that King County would charge a price for the Class A composted Centridry™ product. A price of $5 per wet ton has been established arbitrarily for this alternative; the actual price would need to be established based on an in-depth evaluation of competing products and their market prices.

Alternative 3: Combined Centrifuge Dewatering (25 Percent Solids Cake) and Centridry™ (55 Percent Solids Produced)

This alternative differs from the others in that dewatering would be accomplished by both centrifuges and Centridry™. Specifically, two centrifuges would be installed, plus one complete Centridry™ train. In theory each unit, centrifuge and Centridry™, would be sized for fifty percent of the design solids production, so there would always be standby capacity available (however, similar to Alternatives 1 and 2, the Centridry™ train may need to be converted to dewatering only in order to achieve the capacity to accommodate fifty percent of the peak week solids production). In practice, however, this configuration would provide the flexibility to produce both dewatered cake and dried product simultaneously. Between zero and fifty percent of the South Plant's solids production could be converted to dry product (55 percent solids) via the Centridry™ train; the remainder would be dewatered to 25 percent solids.

In addition to the two new centrifuges and their support systems, all the support systems described in Alternative 1 for each of the three Centridry™ systems would also be provided in this alternative for the one Centridry™ system. A possible layout of Centridry™ and centrifuge equipment within the Dewatering Building is depicted in Figure 5-8.

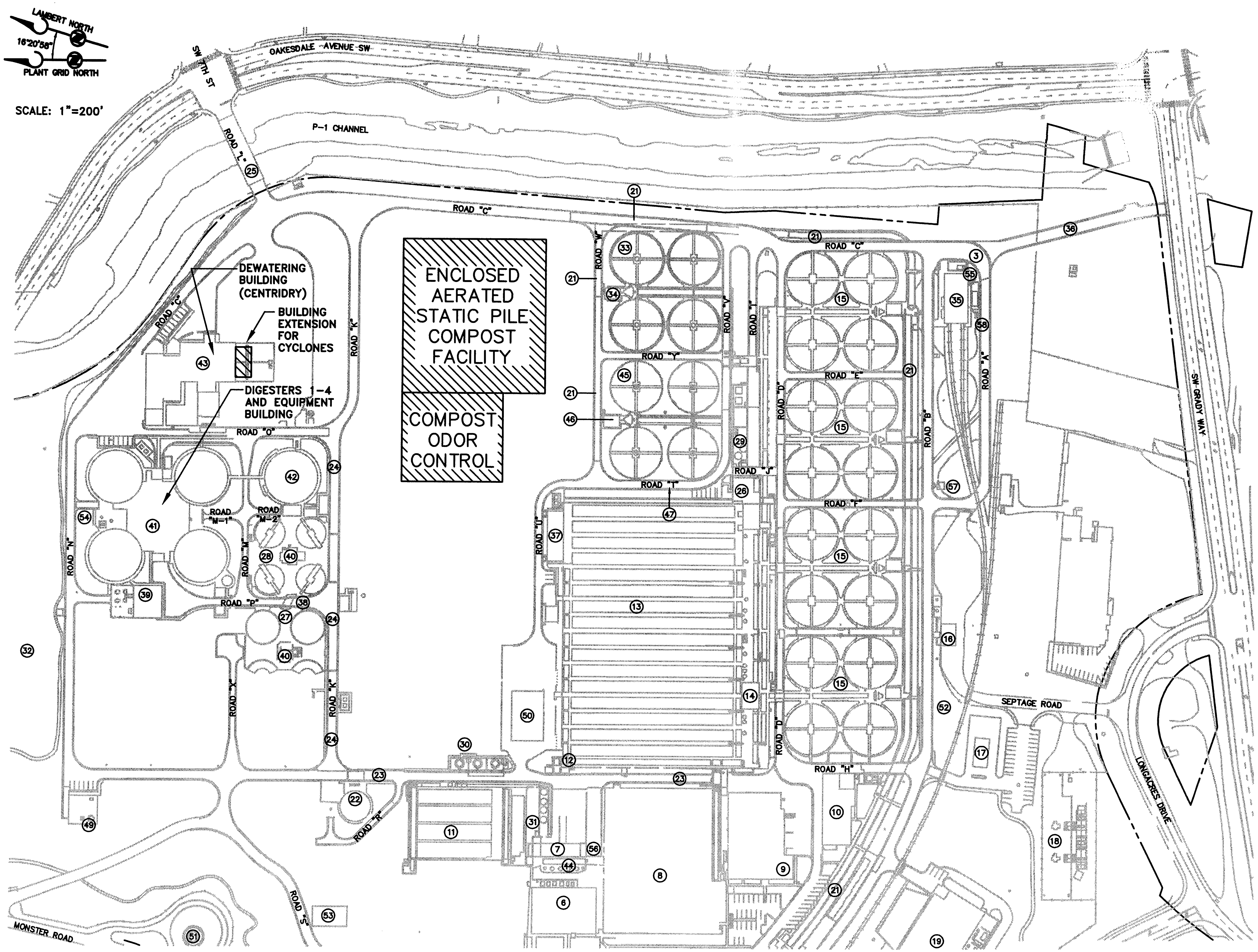
The ability to produce two different biosolids products—25 percent dewatered cake, and 55 percent dried product—allows King County to vary the product mix to match varying demand for each product. Initially, the demand for Centridry™ product would be relatively low; therefore, King County would be able to produce just enough Centridry™ product to match this demand, while continuing to produce dewatered cake that would be accommodated within the existing beneficial-use markets. As demand for Centridry™ product increases, a greater percentage of biosolids production could be shifted to Centridry™ product to meet the demand, up to production capacity of the Centridry™ system. Seasonal variations in demand, if any, could also be accommodated.

As with Alternative 1, a range of beneficial uses of Centridry™ product has been considered. For the fraction of biosolids that are converted to dried product, the sub-alternatives for beneficial use of the biosolids are identical to the sub-alternatives for Alternative 1:

Sub-alternative 3A:	100 percent to eastern Washington agriculture.
Sub-alternative 3B:	50 percent to eastern Washington agriculture; 50 percent to contract composting.
Sub-alternative 3C:	80 percent to eastern Washington agriculture, 20 percent to silviculture.

As with Alternative 1, it is assumed that Centridry™ product would be transported in truck trailers outfitted with on-board aeration for controlling the odors from the product.

For purposes of estimating costs, it is assumed that 33 percent of the South Plant's biosolids production is converted to Centridry™ product; 67 percent will be produced as dewatered cake. Dewatered cake would continue to be beneficially utilized in existing markets.



LEGEND:

- (3) INFLUENT JUNCTION STRUCTURE
- (6) INFLUENT PUMP BUILDING
- (7) GRIT HANDLING STRUCTURE
- (8) SOUTH PRIMARY TREATMENT STRUCTURE
- (9) MAINTENANCE BUILDING
- (10) MAINTENANCE ANNEX
- (11) NORTH PRIMARY TREATMENT STRUCTURE
- (12) PRIMARY EFFLUENT DISTRIBUTION STRUCTURE
- (13) AERATION STRUCTURES 1-4
- (14) SECONDARY CONTROL BUILDING
- (15) SECONDARY SEDIMENTATION STRUCTURES PODS 1-4 AND FLOW CONTROL STRUCTURES 1-4
- (16) SEPTAGE RECEIVING STATION
- (17) MAIN SWITCHGEAR BUILDING
- (18) EDRP SUBSTATION
- (19) EFFLUENT TRANSFER STATION
- (21) CHLORINE CONTACT CHANNELS
- (22) FILTRATE (RECLAIMED WATER) STORAGE TANK
- (23) NORTH-SOUTH TUNNEL (BELOW ROAD)
- (24) EAST-WEST TUNNEL (BELOW ROAD)
- (25) CONSTRUCTION ENTRANCE
- (26) SECONDARY AREA CONTROL CENTER 3
- (27) DISSOLVED AIR FLOTATION THICKENERS 5 AND 6
- (28) DISSOLVED AIR FLOTATION THICKENERS 1-4
- (29) ALUM STORAGE AREA
- (30) SOUTH CHEMICAL STORAGE BUILDING
- (31) PRIMARY ODOR TREATMENT STRUCTURE
- (32) WATERWORKS GARDENS
- (33) SECONDARY SEDIMENTATION TANKS 17-20
- (34) FLOW CONTROL STRUCTURE NO.5
- (35) CHLORINE BUILDING
- (36) EMERGENCY ENTRANCE AT GRADY WAY
- (37) SECONDARY ODOR TREATMENT STRUCTURE
- (38) CENTRAL DIGESTER TUNNEL
- (39) SOLIDS MCC BUILDING
- (40) FOUL AIR TREATMENT STRUCTURES
- (41) ANAEROBIC SLUDGE DIGESTERS 1-4, AND EQUIPMENT BUILDING
- (42) DIGESTED SLUDGE STORAGE TANK
- (43) DEWATERING BUILDING
- (44) INFLUENT DIVISION CHANNEL
- (45) SECONDARY SEDIMENTATION TANKS 21-24
- (46) FLOW CONTROL STRUCTURE NO.6
- (47) SECONDARY N-S TUNNEL BELOW ROAD
- (49) WASTE GAS BURNER FACILITY
- (50) STORAGE BUILDING
- (51) WATER TOWER
- (52) BOEING CHILLER COOLING WATER SUPPLY PUMPING STATION
- (53) WATER REUSE FACILITY
- (54) WASTE GAS SCRUBBERS
- (55) EMERGENCY CHLORINE GAS SCRUBBERS
- (56) GRIT HANDLING STRUCTURE EXTENSION
- (57) SCBA BUILDING
- (58) EMERGENCY STANDBY GENERATOR

Figure 5-7
South Plant Site Plan
Centridry™ With Composting

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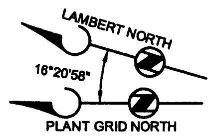


SCALE: 1/16"=1'-0"

NOTES:

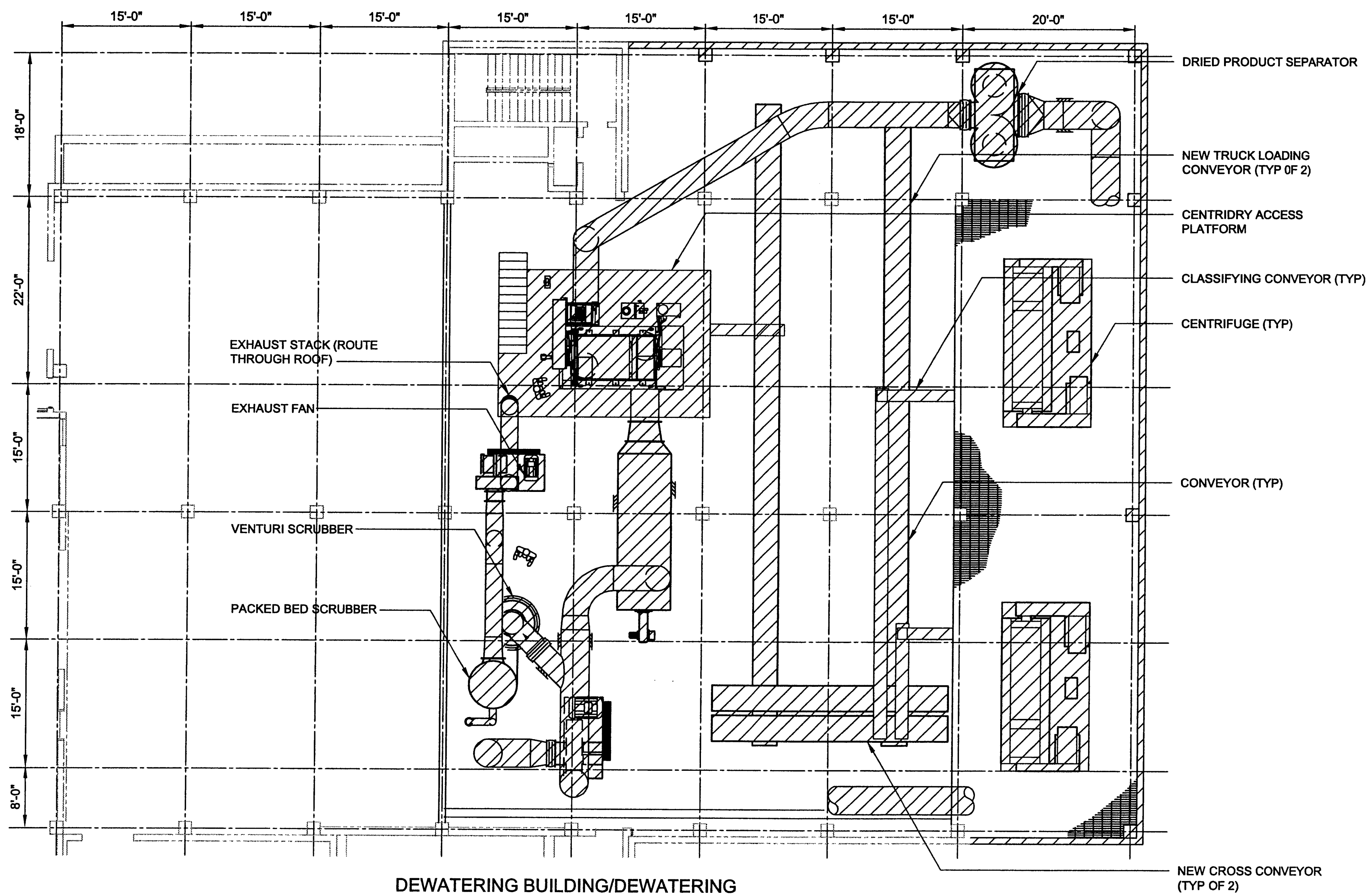
1. TRUCK FUELING AND WASH STATION RELOCATED TO THE SOUTH TO MAKE ROOM FOR BUILDING EXTENSION.
2. SIZE AND RELATIVE CONFIGURATION OF CENTRIDRY CENTRIFUGE, BURNER, FANS, SCRUBBERS, CYCLONES, EXHAUST STACK, AND CONNECTING DUCTWORK PROVIDED BY HUMBOLDT (NOW BAKER PROCESS).

LEGEND:

EXISTING FACILITIES

NEW FACILITIES

NEW EQUIPMENT, FACILITIES



DEWATERING BUILDING/DEWATERING PLAN

Figure 5-8
Alternative 3
Centrifuge and
Centridry™ Equipment Layout

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6

SECTION 6

EVALUATION OF ALTERNATIVES

The alternatives developed in Section 5 are evaluated on the basis of non-cost factors and life-cycle costs. Life cycle costs include estimates of capital and operation and maintenance (O&M) costs, presented in terms of present worth, annual costs, and cost per dry ton of digested solids treated. Life-cycle costs are estimated for activities "within the fenceline" of the South Plant, as well as costs associated with beneficial use of biosolids outside the South Plant's facilities. In addition, the costs of controlling odors from the Centridry™ product are considered in the life-cycle cost evaluation. The issues of product quality, desirability, and marketability, along with other considerations, are addressed in the non-cost evaluation portion of this section.

NON-COST EVALUATION

The following paragraphs document the evaluation of non-cost factors that influence the viability of Centridry™ as a long-term solids dewatering/drying process for King County and South Plant. Non-cost factors include product quality and marketability, process operability, equipment maintainability, odor potential, permitting issues, and siting/land use issues at South Plant. Though deemed non-cost factors, many of these factors influence the life-cycle cost evaluation discussed later in this section.

Product Quality/Marketability

Centridry™ product quality and marketability to end users is the single most important and critical issue influencing King County's evaluation of the Centridry™ process. In order to be considered viable, any biosolids processing technology must produce a product that has value and demand in the beneficial use marketplace (current market or potential future market).

The results of the existing market analyses performed by King County suggest that the straight Centridry™ product (i.e., un-composted Centridry™ product) is not a viable product amongst King County's largest current biosolids users: forest application, wheat farmers, and hop farmers. Issues of odor, dust, and incompatibility with application equipment resulted in strong negative reaction to the product amongst these current users. Based on this preliminary evaluation, it would seem unlikely that straight Centridry™ product would be viable in these markets without further processing and/or significant investment in market development. Together, these markets make up approximately 93 percent of the current end use market for South Plant's biosolids, with the remainder going to commercial composting.[6-1]

Centridry™ was shown to be very amenable to composting, both via on-site bin tests and full-scale tests conducted by LRI and GroCo. A Class A product was readily achieved via composting the Centridry™ product, though the issues of dust and odor still persist in the composted product, but to a lesser extent. Nonetheless, the current market distribution of biosolids end users would not support a large scale shift to a composted Class A product (currently 7 percent of the South Plant's biosolids go to commercial composting). Thus, a new market for Class A composted Centridry™

biosolids would need to be developed to make Centridry™ viable. The sub-alternatives developed for Alternative 2 assume this market has been developed, and further, assume a range of costs and revenue potential from this product.

The new market research portion of this study suggests that a new and potentially viable market for composted Class A biosolids is the western Washington topsoil manufacturing industry. The dryness of the Centridry™ product would be an economic advantage both to the composting process as well as the topsoil manufacturing process. These results are based only on a brief telephone survey; a joint pilot program between King County and interested soils manufacturer(s) is required to better assess the strength of this market.

In comparing the marketability of Centridry™ product (composted or non-composted) to current belt press dewatered cake, or to centrifuge dewatered cake (which would be similar), it is important to recognize that King County has expended years of effort in developing strong and viable markets for dewatered cake. The results from this Centridry™ Demonstration Project, with respect to product quality and marketability, represent only a sketchy and preliminary "snapshot" of this product's potential value in the marketplace. Clearly, if King County moves ahead with implementing Centridry™ full scale at the South Plant, then King County must also be committed to an aggressive and long-term marketing program for the Centridry™ product.

Alternative 3 allows for 50 to 100 percent production of 25 percent total solids dewatered cake (i.e., centrifuge only) to allow King County time to develop strong and viable markets for Centridry™ product, by continuing to produce dewatered cake for current dewatered cake markets (see discussion in Section 5). Alternatives 1 and 2 also include provisions to produce some percentage of dewatered cake in conjunction with Centridry™ product to provide time to develop markets for Centridry™ product.

Operability

Once steady-state operation was achieved (January 1998), the Centridry™ process was found to be very operator-friendly. The PLC controls are effective and reliable at maintaining operation at the operator-selected setpoints, thus producing consistent percent solids product. This confirmed observations made from European Centridry™ installations. The most time-consuming operator function was manually moving the screw conveyor that discharged into the haul trailer, and raking the pile within the trailer (to even the load within the trailer). In a full-scale facility, these functions would be fully automated.

The startup and process optimization periods of the Demonstration Project reinforced the need to sample the dewatered cake from the centrifuge portion of the Centridry™ system. Polymer optimization is critical for optimizing the centrifuge dewatering portion of the system, which in turn is critical to the overall performance of Centridry™. Any design of a full-scale facility must include provisions for sampling dewatered cake alone (without drying) in order to optimize the centrifuge dewatering operation. The current concept of designing the Centridry™ systems to be temporarily converted to centrifuge-dewatering-only addresses this issue.

Maintainability

Each alternative is similar in that the central piece of mechanical equipment is a centrifuge. Centrifuges require regular preventative maintenance, as well as periodic overhauls, but in this respect, each alternative is equivalent. Centrifuge feed pumps and polymer pumps are also common to each alternative.

The alternatives that include Centridry™ systems include many more pieces of mechanical equipment (hot air generators, fans, cyclones, etc.). These equipment items are fairly common in the wastewater industry and, properly specified, they can be robust and reliable. Nevertheless, more pieces of mechanical equipment in these alternatives yield more maintenance requirements.

Odor Potential

In evaluating odor potential, a distinction must be made between odor from the dewatering/ drying process and odor from the product. Odor from the product is addressed under Product Quality/Marketability (above). For the dewatering/drying process, the Demonstration Project confirmed European observations that odor generation is minimal. Compared to the current belt press operation, implementing Centridry™ would likely reduce odor generation and, hence, odor control requirements. This is based on the following:

1. The Centridry™ dewatering/drying process is fully enclosed. Assuming centrate drains are properly vented to odor control, there should be no point to allow odors to escape.

2. Waste hot air circulation from the Centridry™ process is treated independently in a water-based Venturi scrubber. These have been shown to be effective at controlling odors from the Centridry™ process.

The life-cycle cost evaluation presented later in this section assumes that for Alternatives 1 and 2, the existing chemical scrubbing can be mothballed (or moved to serve the composting facility). Odors from the Dewatering Room, with Centridry™ units, should be adequately controlled through activated carbon only. Centridry™ stack odors should be adequately controlled through the Venturi wet scrubber system similar to that used in the demonstration project.

Properly designed, a centrifuge should be less odorous than a belt press operation. Nonetheless, odors will be released from the centrate (via vents) and the dewatered cake. For this reason, it is assumed that Alternatives 0 and 3 will retain the existing two-stage odor scrubbing system (chemical scrubbers followed by activated carbon).

Permitting Issues

Each of the three alternatives would require significant permitting activity. The types of permits that would be required include:

- Air Emissions: Puget Sound Clean Air Agency (PSCAA)
- Shoreline Permit: City of Renton
- Conditional Use Permit: City of Renton
- Various building permits via the City of Renton (Building, Fire, Plumbing, etc.)

Compared to Alternative 0, Alternatives 1, 2, and 3 would likely require more time, effort, and documentation in order to gain a permit from PSCAA. The burning of unscrubbed digester gas in the Centridry™ process represents a significant departure from the current PSCAA air permit for the South Plant.

The current Shoreline Permit Zone associated with the P-1 channel crosses the east edge of the existing Dewatering Building diagonally. Modifications within the Dewatering Building (i.e. centrifuges) would not trigger a Shoreline Permit. However, modifications outside the building (i.e. Centridry™ product cyclones and architectural enclosures) could likely require a Shoreline Permit from the City of Renton.

The effort required to gain a permit from the City of Renton for construction of a composting facility (Alternative 2) could be time consuming and expensive. In contrast, gaining a permit to expand the Dewatering Building only (Alternatives 1 and 3) is likely to be much more straightforward. Modifications confined to within the Dewatering Building (Alternative 0) would require little, if any, permitting activity.

Recent experience on the South Plant Enlargement III construction projects suggests that any building-related permit over which the City of Renton has jurisdiction may be problematic. Adequate time and budget must be planned for in the project schedule to make accommodations to address these permit issues. Building permit issues, however, apply to all alternatives.

Site Issues and Long-Term Planning Issues at the South Plant

Since the South Plant was first constructed over 35 years ago, the entire South Plant site, as well as constructed facilities, have been carefully planned for future expansions. Each of the alternatives under consideration will impact overall site planning to different degrees.

Alternative 2, and in particular the composting facility, has the largest impact on the long-term utilization of the South Plant site. The only area large enough for the enclosed composting facility is in an area designated for future liquid stream process units (aeration basins or trickling filters). A portion of this area has also been allocated for a large power generation facility, though this has not been finalized. Thus, if Alternative 2 is implemented, careful consideration must be given to the regional wastewater treatment planning and power generation implications for the South Plant site.

Implementing either Alternative 1 or 2 will impact the power distribution system for the solids area of the plant. The Centridry™ systems require significantly more connected power than the centrifuge alternative. In all alternatives, new transformers and cables serving the Dewatering Building would require replacement. For Alternative 0, the existing 750 kVA transformers must be replaced with 1,000 kVA transformers, and larger power supply cables. For Alternatives 1 and 2, new 2,000 kVA transformers would be required, plus a new, upsized medium voltage feeder from the plant's Main Switchgear Building. Alternative 3 would be similar to Alternatives 1 and 2 except small transformers may be workable. In each case, substantial modifications to the South Plant's solids treatment area's power supply system would be required.

Construction of the internal perimeter landscaping improvements for the South Plant Enlargement III is nearly complete. Alternatives 0, 1, and 3 would have little impact on site landscaping. Alternative 2, with the large centrally located composting facility, would dramatically alter the landscaping scheme approved by the City of Renton and currently under construction. This may impact the permitting issues described above.

LIFE-CYCLE COST EVALUATION

Life-cycle cost estimates are made up of projected capital costs and estimated annual costs for O&M. The methodology of estimating each, together with the results of the evaluation, is described in the following paragraphs.

Estimated Capital Costs

Each alternative has been evaluated in order to identify the physical features and capital costs required to fully implement the alternatives. Besides costs of equipment and installation, capital costs include estimates or allowances for features such as demolition, structural and architectural modifications, electrical system modifications, utility system modifications, site improvements, testing and commissioning, contractor overhead and profit, bonds, sales tax, and King County's allied costs. Contingencies have also been applied to reflect the conceptual level of development of each alternative. For all non-equipment costs, a 25 percent contingency has been applied. For major equipment for which quotes were obtained (Centridry™ system from Baker Process; centrifuge quote from Alpha-Laval), a 5 percent contingency was applied to the supplier's quoted price. The reduced contingency on equipment costs is justified as these quotes are assumed to be budgetary and should include a supplier's contingency to cover overall cost.

Capital costs are summarized in Tables 6-1, 6-2, 6-3 and 6-4. More detailed breakdown of capital cost estimates is provided in Appendix H. In all cases, costs have been based on a conceptual design of the proposed facilities, manufacturer's quotes on major equipment items, and Brown and Caldwell's experience in estimating construction costs calibrated by recent experience on the construction of Enlargement III facilities. Costs for Centridry™ equipment were provided by Baker Process; see Appendix J.

All costs are expressed in 2001 dollars. Costs are then inflated to the year 2004 (estimated mid-point of construction), using an annual inflation rate of 3 percent.

Capital costs are estimated on the assumption that all new facilities are constructed via a conventional design-bid-build construction contract. Consequently, cost factors have been added for testing and commissioning, Contractor overhead and profit, and bonds and insurance to reflect the total "bid" cost for new facilities in each alternative. Likewise, state sales tax is added to the total.

Table 6-1. Capital Costs for Alternative 0: Replace Belt Presses with Centrifuges

Item	Cost, dollars
Extend Dewatering Building	910,000
Belt press demolition	230,000
Install new centrifuges	4,040,000 (a)
Electrical and controls	1,360,000
Yard modifications	25,000
Subtotal	6,565,000
5 percent contingency on centrifuge equipment	105,000
25 percent contingency on balance of work	1,120,000
Subtotal	7,790,000
Testing and commissioning (2 percent)	160,000
Contractor overhead and profit (15 percent)	1,190,000
Bonds and insurance (4 percent)	370,000
Subtotal	9,510,000
Washington State sales tax (8.6 percent)	820,000
Subtotal	10,330,000
King County allied costs	3,600,000
Total Capital Costs, 2001 dollars	13,930,000
Total Capital Costs, inflated to 2004 dollars	15,230,000

(a) Includes $2.1 million equipment cost for new centrifuges, plus new sludge and polymer feed pumps, conveyors, structural allowance, and appurtenances.

Table 6-2. Capital Costs for Alternative 1: All Centridry™

Item	Cost, dollars
Belt press demolition and construction sequencing	1,675,000 (a)
Install new Centridry™/centrifuge system	9,600,000 (b)
New electrical facilities	3,010,000
Yard modifications	25,000
Subtotal	14,310,000
5 percent contingency on Centridry™/centrifuge equipment	350,000
25 percent contingency on balance of work	1,720,000
Subtotal	16,380,000
Testing and commissioning (2 percent)	330,000
Contractor overhead and profit (15 percent) (c)	1,450,000
Bonds and insurance (4 percent)	730,000
Subtotal	18,890,000
Washington State sales tax (8.6 percent)	1,620,000
Subtotal	20,510,000
King County allied costs	6,470,000 (d)
Initial capital cost to modify haul trucks with aeration	880,000
Total Capital Costs, 2001 dollars	27,860,000
Total Capital Costs, inflated to 2004 dollars	30,450,000

(a) Includes allowance for maintaining dewatering process in operation while centrifuges are installed.

(b) Includes $7,085,000 for equipment provided by Baker Process, installation, allowance for structural modifications to existing building, plus building extension for cyclones and truck loading bays.

(c) Contractor overhead and profit applied to all costs except Centridry™/centrifuge equipment. Baker Process's overhead and profit are included in their quoted equipment costs.

(d) Includes deduction of $710,000 for Baker Process's engineering which is included in cost of Centridry™ system.

Table 6-3. Capital Costs for Alternative 2: All Centridry™ with Composting

Item	Cost, dollars
Belt press demolition and construction sequencing	1,675,000 (a)
Install new Centridry™ equipment	9,600,000 (b)
New electrical facilities	3,155,000
Relocate scrubbers to composting	905,000
Yard modifications	25,000
Subtotal	15,360,000
5 percent contingency on Centridry™ equipment	350,000
25 percent contingency on balance of work	2,070,000
Subtotal	17,780,000
Composting facility (including contingencies)	5,350,000 (c)
Subtotal	23,130,000
Testing and commissioning (2 percent)	460,000
Contractor overhead and profit (15 percent) (d)	2,410,000
Bonds and insurance (4 percent)	1,040,000
Subtotal	27,040,000
Washington State sales tax (8.6 percent)	2,320,000
Subtotal	29,360,000
King County allied costs	9,570,000 (e)
Total Capital Costs, 2001 dollars	38,930,000
Total Capital Costs, inflated to 2004 dollars	42,550,000

(a) Includes allowance for maintaining dewatering process in operation while Centridry™ systems are installed.

(b) Includes $7,085,000 for equipment provided by Baker Process, installation, allowance for structural modifications to existing building, plus building extension with cyclones.

(c) See Appendix C, Table 6, Centridry™ Product Only.

(d) Contractor overhead and profit applied to all costs except Centridry™ equipment costs. Humboldt's overhead and profit are included in their quoted equipment costs.

(e) Includes deduction of $710,000 for Baker Process's engineering which is included in cost of Centridry™ system.

Table 6-4. Capital Costs for Alternative 3: Two Centrifuges and One Centridry™

Item	Cost, dollars
Extend Dewatering Building	305,000
Belt press demolition	230,000
Install 2 new centrifuges, 1 new Centridry™	6,700,000 (a)
New electrical facilities	2,110,000
Yard modifications	25,000
Subtotal	9,370,000
5 percent contingency on Centridry™/centrifuge equipment	215,000
25 percent contingency on balance of work	1,285,000
Subtotal	10,870,000
Testing and commissioning (2 percent)	215,000
Contractor overhead and profit (15 percent) (b)	1,205,000
Bonds and insurance (4 percent)	490,000
Subtotal	12,780,000
Washington State sales tax (8.6 percent)	1,100,000
Subtotal	13,880,000
King County allied costs	4,580,000 (c)
Initial cost to modify haul trucks with aeration	390,000
Total Capital Costs, 2001 dollars	18,850,000
Total Capital Costs, inflated to 2004 dollars	20,600,000

(a) Includes $2,835,000 for equipment provided by Baker Process, installation, $1.4 million for centrifuge equipment, allowance for structural modifications to existing building, and building extension for cyclones and expanded truck bay.

(b) Contractor overhead and profit applied to all costs except Centridry™ equipment. Baker Process's overhead and profit are included in their quoted equipment costs.

(c) Includes deduction of $283,000 for Baker Process's engineering which is included in cost of Centridry™ system.

King County's administrative, engineering, legal, and other administrative costs are included at 35 percent of the total, including sales tax. Thirty-five percent is consistent with recent capital program planning for the Regional Wastewater Services Plan (RWSP). For Alternatives 1, 2, and 3, King County's allied costs have been reduced by Baker Process's cost of engineering for the Centridry™ systems.

Operating and Maintenance (O&M) Costs – Dewatering/Drying

Annual O&M costs for dewatering and/or drying have been estimated for each alternative based on estimated digested solids production for each alternative, for each year of the evaluation period (2005 through 2019). O&M cost estimates are presented in detail in Appendix I as part of the life-cycle cost evaluation. O&M costs are based in part on operating data gathered during the demonstration project; see Appendix B. A summary of O&M costs for each alternative for the design year is presented in Table 6-5.

Table 6-5. Summary of Dewatering, Drying, and Composting Annual O&M Costs for Year 2009 (all costs in 2001 dollars)

O&M cost component	Alternative 0: Centrifuges	Alternative 1: Centridry™	Alternative 2: Centridry™ and composting	Alternative 3: Centridry™ and Centrifuges
Digested solids to dewatering/drying, dry tons/ yr (a)	17,470	17,470	17,470	17,470
Electric power, dollars/year (b)				
Centrifuge dewatering	91,000	--	--	63,000
Centridry™	--	231,000	231,000	72,000
Digester gas usage, dollars/year (c)	--	207,000	207,000	102,000
Chemical costs, dollars/year				
Centrifuge polymer (d)	1,245,000	--	--	830,000
Centridry™ polymer (d)	--	1,245,000	1,245,000	415,000
Odor control (e)	32,000	--	--	32,000
Operating labor, dollars/year (f)				
Centrifuges	371,000	--	--	297,000
Centridry™ (g)	--	371,000	371,000	148,000
Maintenance, dollars/year (h)				
Centrifuge (i)	61,000	--	--	37,000
Centridry™ (j)	--	110,000	110,000	41,000
Composting, dollars/year (k)				
Operating labor	--	--	277,000	--
Maintenance	--	--	44,000	--
Utilities (power and fuel) (l)	--	--	73,000	--
Odor control chemicals	--	--	100,000	--
Miscellaneous	--	--	100,000	--
Total Annual O&M Costs	1,800,000	2,164,000	2,758,000	2,037,000

Please refer to notes on the following page.

Notes for Table 6-5:

(a) Based on RWSP projections, year 2009.
(b) Based on projected electric rates of $0.064 (ref. 6-2) per kw-hr.
(c) For digester gas used as fuel for Centridry™, cost is calculated as loss of net revenue from sales to utility minus cost of scrubbing. This yields a net value of $0.06 per therm (ref. 6-3).
(d) Polymer dosage assumed to be similar for centrifuges and Centridry™; based on pilot centrifuge tests, summer 2001.
(e) Cost of sodium hypochlorite and sodium hydroxide.
(f) Annual cost per full-time employee = $74,150 (ref. 6-3).
(g) Estimated by Baker Process.
(h) Includes labor and materials.
(i) Estimated based on recent bid in Oregon for a 5-year maintenance agreement.
(j) Estimated by Baker Process; includes centrifuge overhaul costs.
(k) See Appendix C-1 for composting cost estimates.
(l) Includes power for odor control.

Beneficial Use Cost

Haul and application costs for beneficial use of biosolids are a significant expense to King County. Compared to the current belt press dewatered cake, each of these alternatives, including Alternative 0, could represent a significant savings to King County by reducing the wet tons of biosolids to be hauled and applied at beneficial-use sites. Also, in the case of Alternative 2, the unit cost of haul and application could be significantly reduced, or actually become a revenue-generating product.

As explained in Section 5, sub-alternatives were developed for each of the alternatives that included Centridry™ in order to reflect a potential range of beneficial use options associated with each product type.

For sub-alternatives A, B, and C, in which Centridry™ product is distributed in various percentages to existing beneficial use markets, current unit costs for haul and application were applied to the "wet tons" of Centridry™ product assigned to each market. In addition, an annual cost of providing aeration of the product was added to the haul and application unit costs.

For Alternative 2, the resulting product, following composting, is Class A and as such significantly higher quality (in terms of pathogen content) than the Class B Centridry™ produced in Alternatives 1 and 3. Therefore, the sub-alternatives associated with the Class A composted product reflect the potentially higher value associated with this product.

For Alternative 0, the 25 percent solids dewatered cake is assumed to be distributed to current beneficial use markets in the same relative proportion as the current belt press dewatered cake. Consequently, a "blended" unit cost for haul and application of dewatered cake, consistent with current costs, is applied to this alternative.

Annual costs for beneficial use of biosolids are summarized in Table 6-6.

Summary of Annual Costs

To compare each alternative and subalternative on the basis of annual costs, the annual O&M costs for dewatering, drying, and composting from Table 6-5 are combined with the annual beneficial use costs from Table 6-6. This is summarized in Table 6-7.

Life-Cycle Cost Evaluation

Capital cost estimates and O&M cost estimates for each alternative are considered together in the life-cycle cost evaluation. Life-cycle costs may be expressed in terms of total annual costs (including annualized capital); and total present worth costs (including the present worth of annual costs). Each of these are presented in the life-cycle cost tables found in Appendix I. A summary of life-cycle present worth costs is presented in Table 6-8. Life-cycle costs were calculated using a discount rate of 6 percent per year, which is consistent with the RWSP's life-cycle cost evaluation.

Life-cycle costs should be considered in light of the degree of work performed on the biosolids, both in terms of mechanical energy (drying) and biological activity (composting). Alternative 0 and the production of 25 percent dewatered cake is considered the baseline for the evaluation. To achieve dewatered solids concentrations in the 50 to 60 percent range requires considerably more energy and work applied to the solids, and consequently it should be expected that the life-cycle cost of this alternative should be significantly higher to reflect the additional mechanical work required.

In Alternative 2, the solids are dried as in Alternative 1, and also subjected to composting to achieve a Class A product. Thus, the biosolids product from Alternative 2 has had both mechanical and biological energy applied to it in order to generate a drier and more pathogen-free material when compared to Alternative 0.

Table 6-6. Summary of Annual Beneficial Use Haul and Application Costs

Annual Cost Component	Alternative 0 Centrifuges	Alternative 1 -- Centridry™			Alternative 2 -- Centridry™ and Composting			Alternative 3 -- Centridry™ and Centrifuges		
		A: 100% to eastern Washington agriculture	B: 50% to agriculture, 50% to composting	C: 80% to agriculture, 20% to silviculture	A: King County pays contractor to distribute	B: Pick-up by user; no cost	C: King County receives revenue from product	A: 100% to eastern Washington agriculture (a)	B: 50% to agriculture, 50% to composting (a)	C: 80% to agriculture, 20% to silviculture (a)
Dewatered cake haul and application cost, dollars per year (b)	2,122,000	--	--	--	--	--	--	1,473,000	1,473,000	1,473,000
Dry product to eastern Washington, dollars per year	--	1,284,000	642,000	1,027,000	--	--	--	390,000	195,000	312,000
Dry product to silviculture, dollars per year	--	--	--	203,000	--	--	--	--	--	60,000
Dry product to commercial composting, dollars per year	--	--	933,000	--	--	--	--	--	292,000	--
Class A product cost (revenue), dollars per year	--	--	--	--	625,000	--	(151,000)	--	--	--
Total	2,122,000	1,284,000	1,575,000	1,230,000	625,000	-0-	(151,000)	1,863,000	1,960,000	1,845,000

(a) Annual costs for Alternative 3 sub-alternatives based on 33% of digested solids (dry weight) converted to Centridry™.
(b) Blended cost, assuming projected distribution of biosolids after 2005: 81 percent to agriculture, 12 percent to silviculture, and 7 percent to commercial composting.

Table 6-7. Summary of Annual Costs (all costs expressed in thousand dollars per year)

Annual Cost Component	Alternative 0 Centrifuges	Alternative 1 -- Centridry™			Alternative 2 -- Centridry™ and Composting			Alternative 3 -- Centridry™ and Centrifuges		
		A: 100% to eastern Washington agriculture	B: 50% to agriculture, 50% to composting	C: 80% to agriculture, 20% to silviculture	A: King County pays contractor to distribute	B: Pick-up by user; no cost	C: King County receives revenue from product	A: 100% to eastern Washington agriculture (a)	B: 50% to agriculture, 50% to composting (a)	C: 80% to agriculture, 20% to silviculture (a)
Dewatering, drying, and composting (from Table 6-5)	1,800	2,164	2,164	2,164	2,758	2,758	2,758	2,037	2,037	2,037
Beneficial use (from Table 6-6)	2,122	1,284	1,575	1,230	625	-0-	(151)	1,863	1,960	1,845
Total annual costs	3,922	3,448	3,739	3,390	3,383	2,758	2,607	3,900	3,997	3,882

(a) Annual costs for Alternative 3 sub-alternatives based on 33% of digested solids (dry weight) converted to Centridry™.

Table 6-8. Summary of Life-Cycle Costs (million dollars)

Life-cycle cost component	Alternative 0: Centrifuge Dewatering	Alternative 1 -- Centridry™			Alternative 2 -- Centridry™ and Composting			Alternative 3 -- Centridry™ and Centrifuges		
		A: 100% to eastern Washington Agriculture	B: 50% to agriculture, 50% to composting	C: 80% to agriculture, 20% to silviculture	A: King County pays contractor to distribute	B: Pick-up by user; no cost	C: King County receives revenue from product	A: 100% to eastern Washington agriculture	B: 50% to agriculture, 50% to composting	C: 80% to agriculture, 20% to silviculture
Capital costs (a)	13.93	27.86	27.86	27.86	38.93	38.93	38.93	18.85	18.85	18.85
Present worth of annual O&M costs	39.70	35.22	38.19	34.67	34.55	28.19	29.73	39.53	40.52	39.34
Total life-cycle present worth costs, dollars	53.63	63.08	66.05	62.53	73.48	67.12	68.66	58.38	59.37	58.19

(a) Capital costs shown as project 2001 costs.

TAB

7

SECTION 7

CONCLUSIONS

The Centridry™ Demonstration Project has been successful in terms of generating valuable information upon which to evaluate this innovative process and its applicability to KCDNR's Wastewater Treatment Division, and in particular to the South Plant. In general, the demonstration project showed the Centridry™ process to be mechanically reliable and operator-friendly. In addition, operating experience on both raw and digested solids confirmed that odor generation and air emissions from the dewatering/drying process are not problematic.

Significant conclusions gained from the Centridry™ Demonstration Project are discussed in the following paragraphs. Conclusions are presented in terms of the project objectives presented in Section 2.

EVALUATE OPERABILITY AND RELIABILITY

In spite of early operating problems with the Centridry™ system (which were ultimately corrected by Humboldt, with assistance from KCDNR staff), the Centridry™ mechanical system confirmed reports and observations from European installations, that the process is reliable and requires minimal routine maintenance, provided operating parameters are controlled within required limits. The system's PLC-based control system performed well in maintaining system operation within operator-selected setpoints and contributed to the positive performance of the system from a reliability and operability perspective.

South Plant staff have known for many years that their digested biosolids are difficult to dewater; i.e., low cake solids are achieved and high polymer dosages are required. The early startup and operational problems encountered in the Centridry™ Demonstration project are attributable, in part, to the nature of South Plant solids. The problems, however, and their ultimate resolution, were useful in understanding key features of the Centridry™ system operation and techniques for optimization. Specifically, the system is vulnerable to inadequate mechanical dewatering. The importance of optimal polymer selection and dosage was demonstrated, as was the difficulty in obtaining dewatered sludge samples upon which to base polymer selection/dosage. This led to the conclusion that a full-scale Centridry™ facility must include provisions to optimize polymer selection/dosage via direct access to dewatered sludge. For this reason, it is recommended that any Centridry™ alternative include provisions to generate dewatered sludge, without drying. This feature also has value in assisting KCDNR in developing markets for Centridry™ product (see discussion under Product Quality and Acceptability).

The early difficulties in startup, and their ultimate resolution, also demonstrated the importance of system optimization utilizing indirect parameters as guides for operations. The conclusion here is that KCDNR must anticipate and plan for significant effort to optimize a full-scale Centridry™ system; but once optimized, KCDNR can expect reliable performance.

ASSESS POTENTIAL FOR ODOR PRODUCTION AND AIR EMISSIONS

Conclusions regarding air emissions, specifically odor emissions, can be segregated into two categories: emissions from the Centridry™ process, and emissions from the Centridry™ product. Each is discussed below.

Centridry™ Process

Experience from the Centridry™ demonstration project leads to the conclusion that odors from the dewatering and drying process would not be problematic. Though odors were detected in and around the Centridry™ Building during operation, they were not judged to be offensive. It is further concluded that in a full-scale facility, odors within the ventilated Dewatering Room would be significantly less than observed from belt press dewatering. Consequently, in a full-scale Centridry™ installation, the Dewatering Building's activated carbon beds may be adequate to meet odor removal goals.

Air emissions, as measured at the Centridry™ system stack, are also judged not to be problematic. If Centridry™ is implemented full scale, it is assumed that the Puget Sound Clean Air Agency (PSCAA) would require a new permit, or an addendum to the existing South Plant permit, to document and set limits for Centridry™ air emissions. Based on very preliminary air modeling performed to date, and current knowledge of PSCAA's requirements, it is not anticipated that air pollution control devices (beyond the Venturi and packed bed scrubbers installed as part of Centridry™) would be required for a full-scale Centridry™ facility. As evidence of this conclusion, the demonstration Centridry™ system was granted a permanent air permit by PSCAA in 1999.

At times during the demonstration project, dust was observed to be a problem at the point of loading dried material into the truck trailer. Dispersion of dust particles by the wind was determined to be contributing to the problem. Also, the problem was observed to be most severe when the system was undergoing startup difficulties, and the system was producing drier than planned product. Ultimately, the dust issue was managed successfully by use of a specially designed truck trailer cover, and the consistent production of 50 to 60 percent product. In a full-scale facility, dried product would be loaded into trucks in a more wind-protected environment. Thus, dust production from the Centridry™ system is not judged to be a problem.

Centridry™ Product

The results of the initial Centridry™ Demonstration Project raised serious questions regarding Centridry™ product quality, especially with respect to dust from the product, as well as odors generated from the product after several days of stockpiling. The results of a follow-up study to focus on product quality issues led to the following conclusions:

1. Product dust can be controlled by maintaining product dryness within the 55 to 60 percent dry solids range. Problematic dust issues can be expected when product dryness exceeds 60 percent. Fortunately, the mechanical and control features of the

Centridry™ system were shown to provide the ability to reliably control product dryness within this range.

2. Odors from the Centridry™ product can be controlled by maintaining the product in an aerated state from the time of production through to its final destination. This conclusion was the result of developing and evaluating, via bench scale batch tests, several hypotheses regarding the mechanism for odor generation. Based on this conclusion, alternatives for Centridry™ include aeration systems for biosolids haul trucks so that the product can be kept under aeration for the duration of its trip to agricultural land application, forestry land application, or commercial composting. Based on the results of the composting bin tests conducted as part of the initial Centridry™ Demonstration Project (1998), it is concluded that composted Centridry™ product will not exhibit objectionable odors.

Though these conclusions indicate that Centridry™ product dust and odors can be controlled, it should also be assumed that Centridry™ product remains vulnerable to odor issues. King County staff, and/or contractors, assigned to manage the beneficial use of King County biosolids must be ever vigilant to avoid circumstances that could result in nuisance odors from the product. Likewise, with experience in Centridry™ process operation and product management, the potential for product-related odors may actually decrease as new and more effective techniques are developed for managing the product.

ASSESS ABILITY TO COMPOST PRODUCT TO CLASS A MATERIAL

The Centridry™ product was shown to be very amenable to composting to Class A standards. The demonstration project showed that composting to achieve Process to Further Reduce Pathogens (PFRP) status can be achieved in a variety of ways and with a variety of bulking agent mixes:

Mixing with yard waste, with aeration
Mixing with sawdust, with aeration
Mixing with sawdust, without aeration
Composting 100 percent Centridry™ product, with aeration

It should be noted that composting 100 percent Centridry™ product without aeration did not achieve PFRP temperatures; therefore, this option should not be used in planning a full-scale facility without further investigation.

Another option which may be evaluated is to convey the warm dried product directly into insulated vessels to retain the heat from the Centridry™ process. Waste heat from the Centridry™ process could be conveyed to the vessels such that temperatures could be held for sufficient time to pasteurize the product. Though technically not a composting process, there may be value in evaluating this type of time-temperature process. This option should be evaluated if KCDNR elects to proceed with a more thorough evaluation of full-scale composting alternatives.

Composting tests using bins at the South Plant provided valuable data on the composting process itself. Composting trials by Land Resources, Inc., and GroCo confirmed the viability of utilizing the product in commercial composting applications. The use of Centridry™ product in a commercial operation is economically attractive because it would lower the cost of bulking agent to achieve a compostable mix.

The Centridry™ product evaluation to date suggests that product odor and dust can be controlled through aeration and careful control of the product dryness, respectively. Nonetheless, all biosolids composting systems are vulnerable to odor production and dusting, especially with a relatively dry material. Therefore, in evaluating full-scale implementation of Alternative 2, Centridry™ with composting, it is recommended that the compost facility be fully enclosed, with the entire enclosed air space ventilated and exhausted to odor control. This includes a biofilter for all compost facility exhausted air, plus first stage chemical scrubbing for building air collected from the most odorous sources within the enclosed building (including Centridry™ product delivery and composting pile aeration air). A positive means of dust control is also recommended for any composting facility.

If Centridry™ followed by composting were to be implemented full scale, a detailed evaluation of composting techniques is recommended. Aerated static pile composting has been used for the cost model developed for life-cycle cost evaluation; this may or may not be the most appropriate or cost-effective composting process for full scale.

Biofiltration and chemical scrubbing of composting odors have been assumed for purposes of developing a cost model. Any detailed full-scale composting process evaluation must include a thorough evaluation of odor control techniques. It is possible that biofiltration by itself could adequately control all odors from a composting process.

ASSESS COST-EFFECTIVENESS OF FULL-SCALE CENTRIDRY™ OPERATION

The life-cycle cost evaluation presented in Section 5 should be considered a planning level evaluation and as such is based on several assumptions which could alter the relative cost-effectiveness of each alternative. Some of the more significant assumptions include the following:

- Biosolids production estimates over the 15-year evaluation period based on RWSP solids production estimates. This evaluation assumes the Brightwater plant will be put on line by 2009.
- The relative cost of each of the O&M cost components, and how each component cost changes with time over the evaluation period. Differing rates of inflation for various O&M cost components may impact the relative life-cycle costs between alternatives.
- The specific terms and conditions of a procurement contract between KCDNR and Baker Process for implementation of Centridry™. Depending on implementation strategies, as well as definition and assignment of risks, Baker Process's costs may be higher or lower than those used in this evaluation.

- Locating the composting facility on the South Plant site; a remote site dedicated to composting may be more appropriate, but would add cost in the form of land purchase (permitting costs are assumed to be similar for any location within King County, including the South Plant).

- Use of the aerated static pile composting process in the cost model; based on more thorough evaluation, another composting process (e.g., in-vessel) may be more cost effective.

The following paragraphs provide a comparison of the relative cost-effectiveness of each alternative, based on the results of the life-cycle cost evaluation presented in Section 5.

Alternative 0: Centrifuges Producing Dewatered Cake

In all cases, Alternative 0—replacing belt presses with centrifuges—is the lowest cost alternative in terms of present worth costs. This alternative represents the least capital cost alternative by a significant margin. With the exception of Alternative 3B, however, this alternative carries the highest annual cost, primarily due to the high cost of haul and application of the wetter, dewatered biosolids. Though this change from belt presses to centrifuges represents a significant change in dewatering technology, Alternative 0 nonetheless represents the "status quo" for King County in biosolids management because it assumes the continuation of dewatered cake biosolids beneficial use programs and costs. The cost-effectiveness of this alternative is vulnerable to changes in biosolids haul and application costs.

Alternative 1: Centridry™ Producing Dried Product

This alternative and its sub-alternatives were developed to determine whether the potential cost savings from using a dried product in King County's beneficial use programs would result in overall savings to King County. The results of the cost evaluation indicate that even though potentially substantial savings in haul and application costs can be achieved, the added capital cost for Centridry™ and the additional operational costs (power, gas, maintenance) more than offset any savings accrued, when compared to Alternative 0. Because of the heavy electric power and gas requirements for operating Centridry™, the alternative is vulnerable to the volatile energy market. Also, if there is difficulty in switching King County's beneficial use application sites from dewatered cake to the drier Centridry™ product, it may be necessary to operate the Centridry™ equipment in a dewatering mode for an extended period. This would delay any savings that would help to offset the higher capital expenditure necessary to implement Centridry™.

Alternative 2: Centridry™ Followed by Composting to Class A

This alternative and its sub-alternatives were developed to determine the potential cost benefits a Class A Centridry™ product may offer relative to dewatered cake (Alternative 0) and straight Centridry™ product (Alternative 1). As was shown in Section 6, potentially large savings in haul and application costs may be achievable if a Class A dried product were produced and utilized in local markets. To achieve a Class A product from Centridry™, however, requires a large capital investment in not only Centridry™ but also a composting facility. Also, the operation of the composting process adds approximately $600,000 in annual costs to this alternative. The result is that each of the Alternative 2 sub-alternatives is significantly higher cost in terms of present worth than any of the other alternatives. It should be noted, however, that this alternative—producing a Class A product—reduces King County's vulnerability to changes in biosolids regulations or public perception of beneficial reuse programs which could place King County's current programs at risk.

Alternative 3: Centrifuges and Centridry™

This alternative was developed to investigate the relative cost of partial implementation of Centridry™, so as to maximize King County's flexibility with respect to biosolids product characteristics. From a cost perspective, however, this alternative appears to offer no advantage to King County when compared to production of dewatered cake. It should be noted, however, that the cost evaluation is based on current beneficial use markets and current unit costs; the relative cost-effectiveness of this alternative would improve if a robust market for Centridry™ product were developed, and at a lower cost than the current markets. The flexibility in product characteristics afforded by this alternative gives King County the ability to develop markets for the Centridry™ product. These new Centridry™ product markets may be less costly to King County than current markets. This alternative places the least capital at risk for implementing Centridry™, and maximizes the potential for long-term reduction in overall costs for biosolids management.

ASSESS PRODUCT QUALITY AND ACCEPTABILITY TO CURRENT AND NEW MARKETS

The Centridry™ Demonstration Project was successful in that it provided operating data and experience to identify the most significant issue of concern regarding full-scale implementation of Centridry™ at the South Plant: product quality, in terms of odors and dust. As explained in Section 3, the Centridry™ product was not well received by KCDNR's largest current biosolids users--Eastern Washington farmers and forest application sites.

As explained in Section 4, the issue of product dust was addressed by controlling the Centridry™ process to consistently produce product with a moisture content of not less than 40 percent. At this level of moisture, product dust formation is attenuated. Also, follow-up investigations into the cause of product odors determined that by maintaining the product in an aerated state, odors could be controlled to an acceptable level. Based on this finding, it is recommended that if the Centridry™ process is adopted, biosolids haul trucks and trailers be outfitted with on-board aeration to prevent the conditions that have been shown to contribute to product odors.

The results of the composting portion of the Centridry™ Demonstration Project yielded positive results. Centridry™ product will compost to yield a Class A product. Also, commercial composters--LRI and GroCo--acknowledged potentially significant commercial/financial benefits from using the drier Centridry™ product versus the wetter dewatered cake. Also, composting appears to reduce the odor potential of the product.

Though the ability to produce Class A biosolids via composting the Centridry™ product appears technically feasible, it is acknowledged that currently, no firm markets for this Class A product exist. Developing robust and viable markets for a new Class A product will require a substantial investment by KCDNR. The local topsoil manufacturing market appears to offer potential; however, the results of a very preliminary telephone survey of commercial topsoil manufacturers indicate that KCDNR must be prepared to invest in a collaborative partnership with these businesses.

The results of this study confirm that the Centridry™ product, either Class B or composted to Class A standards, is viewed by the biosolids marketplace as a different product than the 17 to 18 percent solids, Class B dewatered cake currently produced at the South Plant, and the 26 to 28 percent solids cake produced at West Point. The magnitude of the investment required to develop markets for this new product can be put in perspective by the investment KCDNR has already made in developing markets for the current Class B dewatered cake biosolids product. The success of KCDNR's biosolids management program, as measured by the demand for the current product, is a result of years of effort, research, and partnering with current users. It is conceivable that the Centridry™ product could ultimately enjoy the same demand in the marketplace, but this will require an effort on the part of KCDNR of similar magnitude as that already expended in developing markets for the existing biosolids product.

As indicated above, the Centridry™ product is a different biosolids product than the dewatered cake produced at King County's South Plant and West Point Plant. As indicated above, significant effort may be required to develop markets for this product. Once developed, however, the ability to provide two biosolids products to the marketplace may represent a significant advantage to King County. Specifically, a second biosolids product may allow for more and different markets to be developed by King County. This could be important if, in the future, the demand for dewatered cake diminishes. Or, a second product may serve to increase the demand for King County's biosolids in the marketplace. In either case, the objective would be to continue to develop reliable and robust markets for the beneficial use of King County's biosolids. Centridry™ product will help to achieve this objective, provided odor issues are properly addressed and markets are developed.

Based on the assumptions used in this study's evaluation, King County investment in the Centridry™ process cannot be justified economically. Using current unit costs for biosolids haul and application, and current unit costs for operating cost components (labor, power, chemical, etc.), the added capital cost to implement Centridry™ cannot be made up by reduced annual costs. On the other hand, it must be acknowledged that the economic balance will change dramatically with changes in key unit cost components, especially the cost to haul and apply biosolids. Also, as discussed above, Centridry™ product will provide King County with a second biosolids product which could increase the overall demand for biosolids, and could make Centridry™ more economically attractive. It is recommended that King County continue to monitor the demand for biosolids, and especially the characteristics of biosolids that influence demand, and reconsider Centridry™, or other biosolids processes, when market conditions warrant.

TAB

Appendices

A

TAB

APPENDIX A

REFERENCES

REFERENCES

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B

TAB

APPENDIX B

DEMONSTRATION PROJECT OPERATING DATA

Table B-1: Process Operations Parameters

Date	Steady State Op. [A]	Sludge Feed Flow (gpm)	Sludge Feed Solids (%TS)	Product Total Solids (% TS)	Polymer Feed Flow (gpm)	Centrate Flow (gpm) [B]	Centrate Total Solids (mg/L)	Tower Water Flow (gpm)	Venturi Water Flow (gpm)	Condensate Water Flow (gpm) [C]	Condensate Total Solids (mg/L)	Solids Processed TS (lbs/hr)	Centrate Solids TS (lbs/hr)	Condensate Solids TS (lbs/hr) [D]	Centrifuge capture efficiency TS based (%) [E]	Centrifuge capture efficiency TSS based (%) [F]	Overall capture efficiency TSS based (%)	Polymer Consumed (lb active/hr) [G]	Polymer Required (lb active/ton DS)	Fuel Consumed (cfm) [H]	Fuel consumed (Mbtu/ton DS) [I]	Mechanical Product Water (lb/hr)	Dried Product Water (lb/hr)	Dryer Energy Required (Btu/lb H_2O evap)	Electrical Power (kW) [J]	Electrical Required (kW-hr/lb DS)
9/2/97		20.0	3.4	63.9	3.5	21.1	1,558	89	60	149	364	338	16.4	27.1	95.1	96.2	87.1	6.3	37.4	5.1	4.56	827.6	166.4	1,167	120.3	0.36
9/3/97		25.0	3.2	49.1	4.0	26.2	1,544	89	60	149	342	395	20.2	25.5	94.9	95.9	88.4	7.2	36.6	13.2	10.11	964.5	362.1	3,316	115.7	0.29
9/4/97		25.0	3.1	50.7	4.0	26.2	2,094	89	58	147	334	390	27.5	24.6	93.0	94.3	86.7	7.2	37.1	6.5	5.04	933.0	328.7	1,627	117.8	0.30
9/5/97		25.0	2.7	57.0	4.0	26.6	5,816	89	58	147	370	338	77.4	27.2	77.1	81.1	69.0	7.2	42.9			669.6	176.2		112.7	0.33
9/6/97		25.0	3.5	50.4	4.0	25.9	5,200	89	58	147	338	435	67.4	24.9	84.5	87.4	78.8	7.2	33.3	8.0	5.56	946.2	337.7	1,989	130.5	0.30
9/8/97		25.0	3.1	46.7	4.0	26.2	2,170	89	56	145	322	387	28.5	23.4	92.6	94.1	86.6	7.2	37.5	8.1	6.34	920.7	381.9	2,274	131.5	0.34
9/10/97		25.0	2.8	67.1	4.0	26.5	1,770	90	56	146	324	355	23.4	23.7	93.4	94.7	86.7	7.2	40.7	8.5	7.24	853.3	150.8	1,831		
9/15/97		20.0	3.0	55.7	4.2	22.1	1,630	90	56	146	322	301	18.0	23.5	94.0	95.4	86.2	7.6	50.5	7.1	7.13	728.4	206.6	2,059		
10/21/97		20.0	3.5	77.8	4.0	21.5	2,810	92	56	148	374	354	30.2	27.7	91.5	93.4	83.7	7.2	40.9	9.0	7.69	833.4	84.7	1,819		
10/22/97		16.0	3.6	84.2	4.1	18.0	2,034	88	56	144	382	291	18.3	27.5	93.7	95.4	84.3	7.4	50.9	8.6	8.93	702.2	46.0	1,983	123.0	0.42
10/30/97		20.0	3.3	62.5	3.0	20.6	1,652	92	53	145	272	332	17.1	19.7	94.9	95.8	88.9	5.4	32.7			810.5	177.1		129.0	0.39
1/12/98		25.0	2.9	68.4	3.5	25.9	1,646	89	54	143	287	362	21.3	20.5	94.1	95.2	88.4	6.3	35.0	9.2	7.66	874.8	148.0	1,905	126.5	0.35
1/13/98		30.0			4.2			89	54	143								7.6		7.1					123.8	
1/15/98		25.0	2.9	63.8	2.5	24.9	2,399	90	56	146	231	364	29.9	16.9	91.8	93.0	87.2	4.5	24.9	7.3	6.07	859.2	179.9	1,626	126.6	0.35
1/16/98		24.0	2.8		2.5	24.1	1,537	88	53	141	298	341	18.5	21.0	94.6	95.4	88.4	4.5	26.5	6.2	5.50	829.4		1,131	122.0	0.36
1/19/98		24.0	2.8	58.9	4.0	25.6	2,024	87	52	139	250	331	26.0	17.4	92.2	93.7	86.9	7.2	43.7	6.8	6.21	785.6	201.0	1,760	127.9	0.39
1/20/98		23.0	2.7	71.3	3.0	23.8	3,123	86	52	138	289	313	37.1	20.0	88.1	90.1	81.8	5.4	34.7			709.5	103.0		131.0	0.42
1/21/98		20.0	2.7	69.4	2.5	20.6	1,474	84	52	136	331	269	15.2	22.5	94.4	95.3	86.0	4.5	33.6			653.2	102.3		124.4	0.46
1/23/98	X	25.0	2.9	59.0	3.5	25.9	2,714	86	52	138	194	365	35.2	13.4	90.4	92.1	86.7	6.3	34.7	6.4	5.30	848.9	220.5	1,541	127.2	0.35
1/26/98	X	20.0	2.9	54.9	2.5	20.5		85	49	134	229	287		15.4				4.5	31.5	5.8	6.11	738.6	223.1	1,702	121.6	0.42
1/27/98	X	19.0	2.9	57.8	2.5	19.5	1,279	85	49	134	267	275	12.5	17.9	95.4	96.2	88.9	4.5	32.9	4.0	4.41	674.4	178.6	1,221	119.1	0.43
1/28/98	X	19.0	2.9	61.3	2.5	19.5	1,240	82	49	131	231	276	12.1	15.1	95.6	96.4	90.1	4.5	32.8	4.0	4.39	677.8	157.0	1,162	117.9	0.43
1/29/98	X	20.0	2.8	65.0	2.5	20.5	1,333	82	49	131	266	284	13.7	17.4	95.2	96.0	89.1	4.5	31.8	4.0	4.26	695.8	136.5	1,082	129.9	0.46
1/30/98	X	36.8	2.8	58.7	3.6	36.7	1,439	82	49	131	271	523	26.4	17.8	95.0	95.7	91.6	6.5	24.9	10.7	6.19	1276.9	337.3	1,723	134.2	0.26
2/2/98	X	20.0	2.7	66.3	2.5	20.6	1,570	84	52	136	270	270	16.2	18.4	94.0	95.0	87.2	4.5	33.5			653.3	119.8		134.0	0.50
2/3/98	X	20.0	2.9	64.2	2.5	20.5	1,710	83	51	134	274	287	17.5	18.4	93.9	94.9	87.5	4.5	31.5			693.6	140.3		134.0	0.47
2/4/98	X	20.0	2.9	63.0	2.5	20.4	1,644	84	51	135	269	290	16.8	18.2	94.2	95.2	87.9	4.5	31.2	7.3	7.61	703.1	149.8	1,996	134.0	0.46
2/5/98	X	23.0	2.9	58.1	2.9	23.5	1,716	84	51	135	302	334	20.2	20.4	93.9	95.0	87.8	5.2	31.4	7.3	6.62	806.3	211.9	1,858	134.0	0.40
2/6/98	X	20.0	2.9	63.2	2.5	20.5	1,610	84	52	136	324	285	16.5	22.0	94.2	95.2	86.5	4.5	31.7			691.0	143.5		134.0	0.47
2/9/98		20.0			2.5			86	54	140								4.5		7.9					134.0	
2/12/98	X	30.0			3.7			87	55	142								6.7		7.1					130.0	
2/13/98	X	30.0	2.8	72.5	3.7	30.7	1,472	87	54	141	300	419	22.6	21.2	94.6	95.5	89.5	6.7	32.0			1018.8	142.4		129.0	0.31
2/17/98	X	30.0	2.6	58.7	4.0	31.3	1,944	86	54	140	365	384	30.4	25.6	92.1	93.4	85.4	7.2	37.7			910.0	231.2		132.0	0.34
2/18/98	X	30.0	2.6	53.2	4.0	31.3	1,360	85	54	139	306	384	21.3	21.3	94.5	95.4	88.9	7.2	37.7	8.2	6.46	933.5	300.5	1,960	132.0	0.34
2/19/98	X	30.0			4.0			85	54	139								7.2							132.0	
2/20/98	X	30.0			4.0			85	56	141								7.2							124.0	
2/23/98	X	30.0	3.1	60.1	4.0	30.7	1,781	87	56	143	329	458	27.4	23.5	94.0	95.1	88.9	7.2	31.6			1106.9	269.8		133.0	0.29
2/24/98	X	30.0	2.9	57.54	4.0	30.9	1,588	86	56	142	295	428	24.6	21.0				7.2	33.8				282.1			
2/25/98	X	30.0	2.7	59.15	3.8	30.8	1,576	86	56	142	295	408	24.3	21.0				6.8	33.2	6.6			250.7			
2/27/98	X	30.0	2.9	54.82	3.6	30.5		86	55	141	300	441		21.2				6.5	29.5				346.3			
3/2/98	X	30.0	2.8	52.82	4.0	31.0	1,729	87	57		261	419	26.8					7.2	34.6						132.0	0.32
3/3/98	X	30.0	2.9	57.25	3.8	30.7	1,680	87	57		322	432	25.8					6.9	31.8						135.0	0.31
3/5/98	X	30.0	2.9	57.18	3.8	30.7	1,634	87	59		319	435	25.1					6.9	31.6						131.0	0.30
3/6/98	X	30.0	3.0	64.89	3.9	30.7	1,600	85	58		269	443	24.6					7.1	31.9						126.0	0.28
3/7/98	X	30.0		64.13	3.9			85	58									7.1							124.0	
3/8/98	X	30.0		63.97	3.9			84	56									7.1								
3/10/98	X	30.0	3.0	52.56	3.9	30.7	1,656	85	58		816	447	25.4					7.1	31.6						131.0	0.29
3/11/98		22.0		73.23	3.9			86	58									7.1							116.0	
(undigested)																										
3/23/98				45.55																						

Table B-1: Process Operations Parameters

Data Summary	Sludge Feed Flow (gpm)	Sludge Feed Solids (%TS)	Product Total Solids (% TS)	Centrate Total Solids (mg/L)	Condensate Total Solids (mg/L)	Centrifuge capture efficiency TS based (%)[a]	Centrifuge capture efficiency TSS based (%)[e]	Overall capture efficiency TSS based (%)	Polymer Required (lb active/ton DS)	Fuel consumed (Mbtu/ton DS)[n]	Dryer Energy Required (Btu/lb H_20 evap)	Electrical Required (kW-hr/lb DS)
(Overall)												
average	25.2	2.9	61.2	1,967	313	92.8	94.1	86.5	34.6	6.34	1,801	0.37
maximum	36.8	3.6	84.2	5,816	816	95.6	96.4	91.6	50.9	10.11	3,316	0.50
minimum	16.0	2.6	46.7	1,240	194	77.1	81.1	69.0	24.9	4.26	1,082	0.26
(Steady-state)												
average	26.6	2.8	60.0	1,632	308	94.1	95.1	88.3	32.4	5.71	1,583	0.37
maximum	36.8	3.1	72.5	2,714	816	95.6	96.4	91.6	37.7	7.61	1,996	0.50
minimum	19.0	2.6	52.6	1,240	194	90.4	92.1	85.4	24.9	4.26	1,082	0.26

Notes:
A - Steady-state operation defined by a minimum of 10 hours of daily operation with no "logged" processing issues
B - Assumed 28 %TS on mechanical side of centrifuge (from dewatering trial data) and ignored solids fraction of polymer feed
C - Value is the sum of the flows through packed tower and venturi scrubbers
D - Assumed C3 water total solids content of 10 mg/L (from previous lab results)
E - Worst case use of total solids values (improved efficiency with total suspended solids values)
F - Assumes that TSS/TS ratio is 0.94
G - Batch tank of 318 gallons in which 2.5 gallons has been added as neat polymer (46 % active portion)
H - From daily process checklist
I - Propane constant 2,522 Btu/cf
J - Sum of feeder A and feeder B values

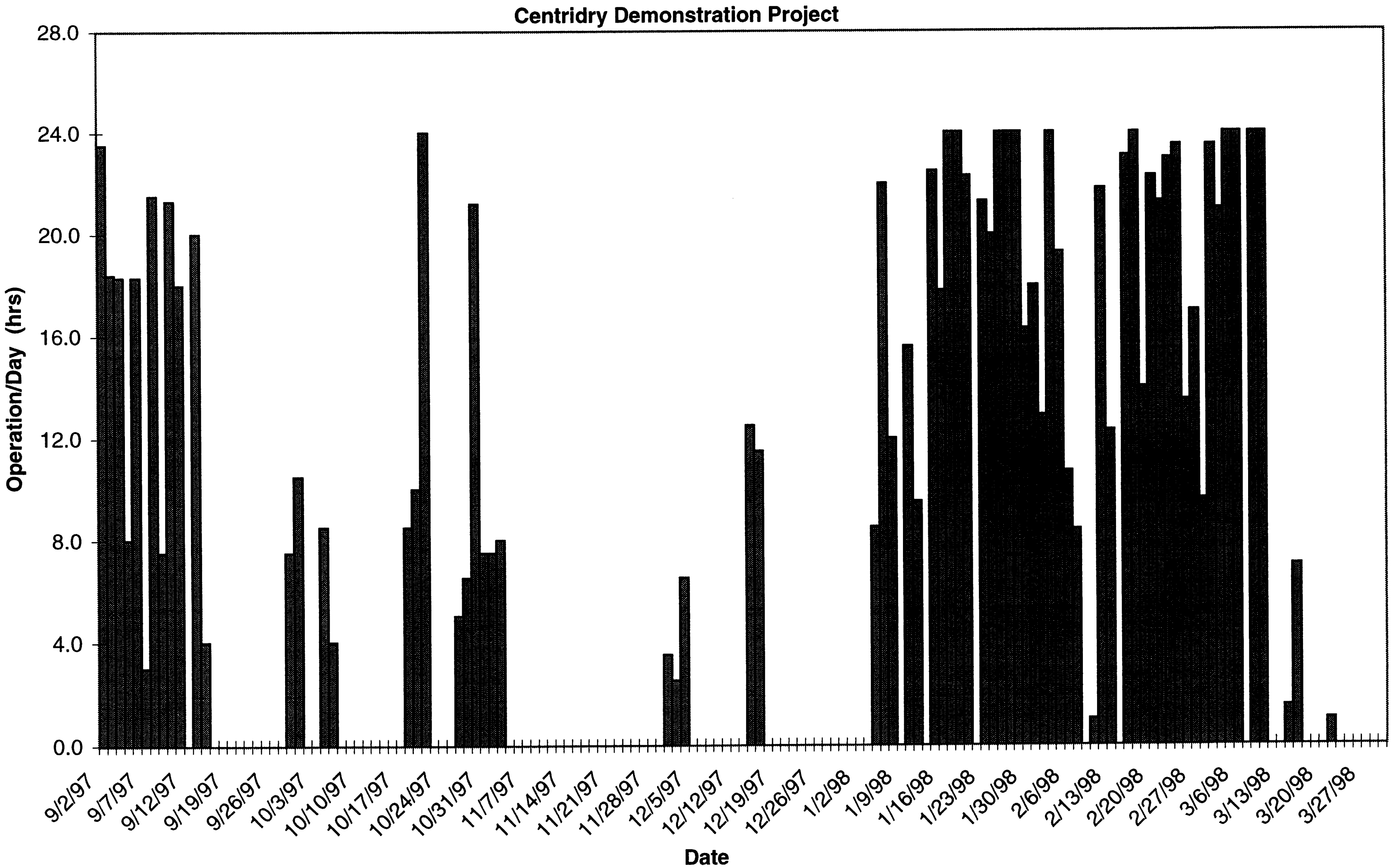

Figure B-1: Facility Operation

Table B-2: Operations Log

Date	Day of Week	Run Time (hrs) [A]	Operations Log Summary
9/2/97	Tues	23.5	Start of Demonstration Testing, System started in morning, Samples collected by UW graduate student for BMP biosolids study (odor production), Optimizing system parameters
9/3/97	Wed	18.4	Adjusted burner setpoint to control product %TS, Noted that the burner end of hot gas generator was extremely hot (unable to touch) - will investigate and contact Humboldt
9/4/97	Thurs	18.3	System shutdown at 0125 hrs, Arrived at 0620 hrs to find fans still running and water discharging from feed end of centrifuge, Found C2 water flush solenoid valve leaking - isolated, Restarted system at 1235 hrs.
9/5/97	Fri	8.0	Talked with Humboldt about process - fan control, excessive heat at burner end of hot gas generator, purge water solenoid failure, Cyclone high level alarm at 1458 hrs and system shutdown, Discovered material in cyclone separator
9/6/97	Sat	18.3	Received word that product biosolids trailers did not completely unload at end user site - residual in returning trailer, Cleaned out cyclone separator, Reset exhaust fan oxygen level control to reduce heating at burner end, Started process at 1245 hrs.
9/7/97	Sun	3.0	Noted leak at centrate cover on centrifuge, changed operating parameters due to poor centrate, burner end of hot gas generator cooler - exhaust fan setpoint change helped, Manual system shutdown at 1005 hrs - due to leak on centrate cover
9/8/97	Mon	21.5	Fixed centrifuge cover leak, Started system at 0840 hrs, Adjusted centrifuge condition, Product Odor Meeting held with conclusion to stockpile product at Boulder Park and try mixing product with dewatered cake.
9/9/97	Tues	7.5	System operated throughout the day, Product sampling throughout the day to correlate gas burner temperature setpoint and product %TS, "Accidental" emergency stop actuated at 1435 hrs leading to dewatered product in the air ducting, Evening cleanup.
9/10/97	Wed	21.3	System started at 0700 hrs, Several process changes initiated during startup.
9/11/97	Thurs	18.0	System operating throughout the day, System alarm (cyclone high level), System secured and cyclone cleared, System restarted at 2030 hours after trailer change, System alarm (cyclone high level) after several hours, System secured.
9/12/97	Fri	0.0	Material discovered in cyclone and cleaned out, Plan to delay startup to conserve on polymer (additional on order).
9/15/97	Mon	20.0	Cleaned cyclone from previous shutdown, Discovered several system circuit breakers tripped (logged and reset), System started at 1100 hrs.
9/16/97	Tues	4.0	Numerous system alarms throughout day, Discovered water in air exit ducting, Cleaned and dried air system, Lost digested feed solids due to cleaning of facility blended storage tank, Installed new polymer bin, Compost bin testing (Series 1) started.
9/17/97	Wed	0.0	No solids feed due to facility digester cleaning preparations.
9/18/97	Thurs	0.0	Attempted to start system with no luck, Suspect poor mechanical dewatering due to inconsistent solids feed.
9/19/97	Fri	0.0	Digester # 2 solids quality (vs. blended storage tank) causing mechanical dewatering inconsistency (requires constant attention).
9/22/97	Mon	0.0	Decision to delay system startup due to solids feed quality.
9/23/97	Tues	0.0	Startup delay due to facility back-up in sanitary drain system (from digester cleaning operations).
9/24/97	Wed	0.0	Startup delay due to facility back-up in sanitary drain system (from digester cleaning operations).
9/25/97	Thurs	0.0	Startup delay due to facility back-up in sanitary drain system (from digester cleaning operations).
9/26/97	Fri	0.0	Startup delay for blended storage tank filling.
9/29/97	Mon	0.0	Startup delay for blended storage tank filling.
9/30/97	Tues	7.5	System started at 1255 hrs, System alarm (cyclone high level) leading to automated secure.
10/1/97	Wed	10.5	System started at 0800 hrs, "Power bump" caused automatic secure in early afternoon, System restarted at 1430 hrs, System alarm (cyclone high level) at 1830 hrs leading to automated secure.
10/2/97	Thurs	0.0	No operation - facility dewatering shutdown.
10/3/97	Fri	0.0	No operation - facility dewatering shutdown.
10/6/97	Mon	8.5	Numerous system alarms during operation throughout day, Cleaned solids and water from air conveyance system ducting, AmTest Air Quality setting up equipment for stack emissions sampling.
10/7/97	Tues	4.0	Troubleshooting damper on recirc fan, System startedt 0800 hrs, Difficult to maintain steady-state operation due to decreased air conveyance flow, AmTest collected limited data, Automated system shutdown under alarm (low recirc air velocity).
10/8/97	Wed	0.0	Troubleshooting air conveyance system problem (decreased air velocity).
10/9/97	Thurs	0.0	Continued troubleshooting air conveyance system.
10/10/97	Fri	0.0	Continued troubleshooting air conveyance system, Plan to install inspection ports in air conveyance system.
10/13/97	Mon	0.0	Continued troubleshooting air conveyance system.
10/14/97	Tues	0.0	Continued troubleshooting air conveyance system.
10/15/97	Wed	0.0	Continued troubleshooting air conveyance system.
10/16/97	Thurs	0.0	Continued troubleshooting air conveyance system.
10/17/97	Fri	0.0	Continued troubleshooting air conveyance system.
10/20/97	Mon	8.5	Several system startups with numerous alarms (low CD exit temperature, low recirc air velocity, and high CO).
10/21/97	Tues	10.0	Troubleshooting polymer batching system - batch did not transfer and timer locked, AmTest Air Quality successfully completed one sampling run, Resolved polymer skid problem, System restarted at 1400 hrs, Compost bin testing (Series 1) completed.
10/22/97	Wed	24.0	High CO levels noted by Operations, Continued operation.
10/23/97	Thurs	0.0	Automatic system secure following power surge, Attempted system restart with no luck, Alarm condition (cyclone high level), Troubleshooting revealed that the cyclone high level sensor failed due to excess exposure to water.
10/24/97	Fri	0.0	No system operation - waiting for replacement high level sensor.
10/27/97	Mon	0.0	No system operation - waiting for replacement high level sensor.
10/28/97	Tues	5.0	Several attempts to operate system but air conveyance system continues to be a problem - low air flow velocity.
10/29/97	Wed	6.5	Continued troubleshooting air conveyance system, AmTest Air Quality successfully completed two sampling runs at varying process operating conditions.
10/30/97	Thurs	21.2	Continued troubleshooting air conveyance system
10/31/97	Fri	7.5	Continued troubleshooting air conveyance system.
11/3/97	Mon	7.5	System startup at 0800 hrs. Automatic system secure following alarm (recirc air velocity) at 1525 hrs.
11/4/97	Tues	8.0	System startup with alarm (recirc air velocity). Numerous alarms throughout the day with final shutdown on alarm (low CD exit temperature)
11/5/97	Wed	0.0	No Operation - continued troubleshooting air conveyance system.
11/6/97	Thurs	0.0	No Operation - continued troubleshooting air conveyance system.
11/7/97	Fri	0.0	No Operation - continued troubleshooting air conveyance system.
11/10/97	Mon	0.0	No Operation - continued troubleshooting air conveyance system.
11/11/97	Tues	0.0	No Operation - continued troubleshooting air conveyance system.
11/12/97	Wed	0.0	No Operation - continued troubleshooting air conveyance system.
11/13/97	Thurs	0.0	Air conveyance system checkouts performed at various temperatures.
11/14/97	Fri	0.0	No Operation - Humboldt preparing "trailer mounted" dewatering centrifuge for operation on digested sludge in an effort to optimize mechanical dewatering.

Table B-2: Operations Log

Date	Day of Week	Run Time (hrs) [A]	Operations Log Summary
11/17/97	Mon	0.0	No Operation - Humboldt preparing "trailer mounted" dewatering centrifuge for operation on digested sludge in an effort to optimize mechanical dewatering.
11/18/97	Tues	0.0	No Operation - Humboldt preparing "trailer mounted" dewatering centrifuge for operation on digested sludge in an effort to optimize mechanical dewatering.
11/19/97	Wed	0.0	Humboldt operated "trailer mounted" dewatering centrifuge with resulting cake values of between 27 and 28 %TS.
11/20/97	Thurs	0.0	Humboldt continued operating "trailer mounted" dewatering centrifuge to collect additional information and optimize polymer dosing.
11/21/97	Fri	0.0	No operation - Humboldt assessing all the collected information from air conveyance system checkouts and dewatering centrifuge operation, Thanksgiving Holiday.
11/24/97	Mon	0.0	No operation - Humboldt assessing all the collected information from air conveyance system checkouts and dewatering centrifuge operation, Thanksgiving Holiday.
11/25/97	Tues	0.0	No operation - Humboldt assessing all the collected information from air conveyance system checkouts and dewatering centrifuge operation, Thanksgiving Holiday.
11/26/97	Wed	0.0	No operation - Humboldt assessing all the collected information from air conveyance system checkouts and dewatering centrifuge operation, Thanksgiving Holiday.
11/27/97	Thurs	0.0	No operation - Humboldt assessing all the collected information from air conveyance system checkouts and dewatering centrifuge operation, Thanksgiving Holiday.
11/28/97	Fri	0.0	No operation - Humboldt assessing all the collected information from air conveyance system checkouts and dewatering centrifuge operation, Thanksgiving Holiday.
12/1/97	Mon	0.0	No operation - Humboldt assessing all the collected information from air conveyance system checkouts and dewatering centrifuge operation, Thanksgiving Holiday.
12/2/97	Tues	3.5	System operated to test conclusions reached in data analysis, Numerous automated system shutdowns initiated by alarm(low CD exit temperature).
12/3/97	Wed	2.5	System operated in the morning with numerous shutdowns, **CHECKED CENTRIFUGE AND DISCOVERED 3 OF 4 CENTRATE PORTS PLUGGED WITH PLASTIC DEBRIS**, Centrifuge ports were cleaned.
12/4/97	Thurs	6.5	System operated to collect additional data for review, Operation during entire day with no shutdowns - it appears the problem is solved.
12/5/97	Fri	0.0	No operation until new demonstration facility trailer tarp is completed - Operations concern with solids discharge from conveyor in windy conditions.
12/8/97	Mon	0.0	No operation until new demonstration facility trailer tarp is completed - Operations concern with solids discharge from conveyor in windy conditions.
12/9/97	Tues	0.0	No operation until new demonstration facility trailer tarp is completed - Operations concern with solids discharge from conveyor in windy conditions.
12/10/97	Wed	0.0	No operation until new demonstration facility trailer tarp is completed - Operations concern with solids discharge from conveyor in windy conditions.
12/11/97	Thurs	0.0	No operation until new demonstration facility trailer tarp is completed - Operations concern with solids discharge from conveyor in windy conditions.
12/12/97	Fri	0.0	Fit check of new trailer tarp completed.
12/15/97	Mon	0.0	Trailer tarp and associated pulley system installed.
12/16/97	Tues	12.5	System demonstration run to verify air conveyance system problem solved, Operation with no shutdowns.
12/17/97	Wed	11.5	System demonstration run to verify air conveyance system problem solved, Operation with no shutdowns.
12/18/97	Thurs	0.0	Secured system for the Holidays with planned startup on 6 Jan.
12/19/97	Fri	0.0	Secured system for the Holidays with planned startup on 6 Jan.
12/22/97	Mon	0.0	Secured system for the Holidays with planned startup on 6 Jan.
12/23/97	Tues	0.0	Secured system for the Holidays with planned startup on 6 Jan.
12/24/97	Wed	0.0	Secured system for the Holidays with planned startup on 6 Jan.
12/25/97	Thurs	0.0	Secured system for the Holidays with planned startup on 6 Jan.
12/26/97	Fri	0.0	Secured system for the Holidays with planned startup on 6 Jan.
12/29/97	Mon	0.0	Secured system for the Holidays with planned startup on 6 Jan.
12/30/97	Tues	0.0	Secured system for the Holidays with planned startup on 6 Jan.
12/31/97	Wed	0.0	Secured system for the Holidays with planned startup on 6 Jan.
1/1/98	Thur	0.0	Secured system for the Holidays with planned startup on 6 Jan.
1/2/98	Fri	0.0	Secured system for the Holidays with planned startup on 6 Jan.
1/5/98	Mon	0.0	Secured system for the Holidays with planned startup on 6 Jan.
1/6/98	Tues	8.5	System operated throughout the day to optimize process control.
1/7/98	Wed	22.0	System operating well with continued process optimization.
1/8/98	Thurs	12.0	System operated successfully with sludge feed flow as high as 40 gpm.
1/9/98	Fri	0.0	System secured for the weekend.
1/12/98	Mon	15.6	Several minor problems associated with cold weather - all solved, System started at 1530 hrs, Samples collected by UW graduate student for BMP biosolids study (odor production).
1/13/98	Tues	9.5	System secured for trailer change.
1/14/98	Wed	0.0	Problem with hot gas generator during startup - burner proceeds to shutdown following normal purge cycle, Traced problem to faulty valve train - cold weather causes the valve/regulator assembly failure, Solved Problem with external heating.
1/15/98	Thurs	22.5	System started at 0835 hrs, Operation with no problems.
1/16/98	Fri	17.8	Continued operation, Lost solids feed due to power "bump", Operations secured system via automated shutdown.
1/19/98	Mon	24.0	System started and operated throughout the day, Slipping in solids feed pump required use of valve for throttling flow during startup - talked to Humboldt about replacing stator, Forced to secure system for short period of time to change trailer.
1/20/98	Tues	24.0	System operated the entire day, Solids feed pump capacity has decreased due to worn stator.
1/21/98	Wed	22.3	System operated until trailer was full, Problem maintaining feed flow level due to worn stator on pump, Operator secured system via automated shutdown.
1/22/98	Thurs	0.0	System secured for trailer change, Performed checkouts of sludge feed system and polymer system to verify data.
1/23/98	Fri	21.3	System started at 0940 hrs, Steady-state operation until Saturday morning and secured for weekend.
1/26/98	Mon	20.0	System started at 1015 hrs, Adjusting operating parameters throughout the day to optimize process operation, Steady-state operation.
1/27/98	Tues	24.0	Continued steady-state operation, Compost bin testing (Series 2) started.
1/28/98	Wed	24.0	Continued steady-state operation, Followed recently filled trailers to Snoqualmie Tree Farm to observe application - noted odors during unloading, some product was moving in air under windy conditions.
1/29/98	Thurs	24.0	Continued steady-state operation, Noted the burner end of hot gas generator at elevated temperature - adjusted exhaust blower setpt to cool, Conveyor shaking violently for short period of time in afternoon - assume product buildup leading to imbalance.
1/30/98	Fri	16.3	Continued steady-state operation, Humboldt conducted performance testing with feed rates from 20 to 45 gpm, System secured for the weekend.
2/2/98	Mon	18.0	System started at 1225 hrs, Steady-state operation throughout the day.

Table B-2: Operations Log

Date	Day of Week	Run Time (hrs) [A]	Operations Log Summary
2/3/98	Tues	12.9	Steady-state operation throughout the day, AmTest Air Quality setting up for emissions sampling, Continued problem with the product discharge conveyor shaking - used rubber hammer to dislodge material and cleaned out with water.
2/4/98	Wed	24.0	Steady-state operation throughout the day, AmTest Air Quality successfully completed three sampling runs at various process operating conditions.
2/5/98	Thurs	19.3	Steady-state operation throughout the day, AmTest Air Quality successfully completed an additional three sampling runs at various process operating conditions, Operations secured the system in the evening due to excessive conveyor vibration.
2/6/98	Fri	10.7	Cleaned conveyor with water flush, System started at 1115 hrs, Operations secured in the evening following fill of trailer.
2/9/98	Mon	8.4	Cleaned conveyor with water flush, System started at 1050 hrs, Lost solids feed - system continued to operate for three hours before being secured.
2/10/98	Tues	0.0	Evaluating the impact to system of operation without feed solids - possible heat damage to centrifuge, Humboldt performed centrifuge checkout in the afternoon with no anomalies.
2/11/98	Wed	1.0	Changed stator and adjusted the VFD on the solids feed pump, System started at 1630 hrs and operated for 1 hour to verify no hardware damage - none noted.
2/12/98	Thurs	21.8	System started at 0830 hrs, Steady-state operation.
2/13/98	Fri	12.3	Continued steady-state operation, Secured system in the afternoon for the weekend.
2/16/98	Mon	0.0	No operation.
2/17/98	Tues	23.1	System started at 0745 hrs, Steady-state operation.
2/18/98	Wed	24.0	Continued steady-state operation.
2/19/98	Thurs	14.0	Continued steady-state operation, System secured at 2100 hrs after filling last available trailer.
2/20/98	Fri	22.3	System startup and steady-state operation, system secured at 1400 hrs for the weekend.
2/23/98	Mon	21.3	System startup at 0900 hrs, steady-state operation, Compost bin testing (Series 2) completed.
2/24/98	Tues	23.0	Continued steady-state operation.
2/25/98	Wed	23.5	Continued steady-state operation, Humboldt conducting evaluation of polymer dosing with dilution water.
2/26/98	Thurs	13.5	Continued steady-state operation, Humboldt evaluated polymer dosing with dilution water, System shutdown due to high scrubber exit temperature - incorrect adjustment of venturi throat plug, Mixing demo conducted with dewatered cake and product.
2/27/98	Fri	17.0	Readjusted scrubber venturi position, System started and operated at steady-state, System secured for the weekend.
3/2/98	Mon	9.6	System startup at 0745 hrs, Steady-state operation, Secured after trailer filled.
3/3/98	Tues	23.5	System startup and steady-state operation, System secured at 1400 hrs for the weekend, Trailers hauled product to LRI for composting (Full-scale compost study).
3/4/98	Wed	21.0	Continued steady-state operation, Secured system after trailer filled.
3/5/98	Thurs	24.0	System startup and steady-state operation.
3/6/98	Fri	24.0	Continued steady-state operation, Operated system throughout the weekend to fill three trailers for compost study.
3/9/98	Mon	0.0	Trailers hauled to GroCo for composting (Full-scale compost study)
3/10/98	Tues	24.0	System startup and steady-state operation.
3/11/98	Wed	24.0	Continued steady-state operation, System secured after filling trailer.
3/12/98	Thurs	0.0	No operation, Compost bins (Study Series 2) were rewetted to investigate whether curing was complete.
3/13/98	Fri	0.0	No operation.
3/16/98	Mon	1.5	System startup and operation by Humboldt to perform gas consumption tests, System secured following testing, **DISCOVERED PLUGGED CENTRIFUGE CENTRATE PORTS AGAIN**, (10) - 55 gal drums were filled with product for pelletizing in Oregon.
3/17/98	Tues	7.0	System startup and operation by Humboldt to perform gas consumption and polymer tests, System secured following testing.
3/18/98	Wed	0.0	No operation - preparing for undigested solids feed.
3/19/98	Thurs	0.0	No operation - preparing for undigested solids feed.
3/20/98	Fri	0.0	No operation - preparing for undigested solids feed.
3/23/98	Mon	1.0	System startup and operation with undigested solids feed, Operation for approximately 1 hour, Problem with maintaining proper polymer dosing due to feed solids fluctuations.
3/24/98	Tues	0.0	Attempted system operation on undigested solids feed but problems with effective polymer dosing (feed solids fluctuations), AmTest Air Quality collected emission gas samples.
3/25/98	Wed	0.0	Attempted system operation on undigested solids feed but problems with effective polymer dosing (feed solids fluctuations).
3/26/98	Thurs	0.0	Attempted system operation on undigested solids feed but problems with effective polymer dosing (feed solids fluctuations).
3/27/98	Fri	0.0	Attempted system operation on undigested solids feed but problems with effective polymer dosing (feed solids fluctuations).
3/30/98	Mon	0.0	No operation.
3/31/98	Tues	0.0	End of Demonstration Period.

Notes

A - Run time is based on operations shift hours (for example, 23.5 hours on 9/2/97 started at 0700 hrs on 9/2/97 and stopped at 0630 hours on 9/3/97)

Table B-3: Process Mass Balance

Date	Steady State Op.[A]	Sludge Feed Flow (gpm)	Sludge Feed Solids (%TS)	Product Total Solids (% TS)	Polymer Feed Flow (gpm)	Centrate Flow (gpm)[B]	Centrate Total Solids (mg/L)	Tower Water Flow (gpm)	Venturi Water Flow (gpm)	Condensate Water Flow (gpm)[C]	Condensate Total Solids (mg/L)	Feed TS (lbs/hr)	Centrate TS (lbs/hr)	Condensate TS (lbs/hr)[D]	Product TS (lbs/hr)	Feed TKN (mg/L)	Feed TKN (lbs/hr)	Centrate TKN (mg/L)	Centrate TKN (lbs/hr)	Condensate TKN (mg/L)	Condensate TKN (lbs/hr)	Product TKN (mg/kg wet)	Product TKN (lbs/hr)	Overall TKN Accounted (%)	Feed TP (mg/L)	Feed TP (lbs/hr)	Centrate TP (mg/L)	Centrate TP (lbs/hr)	Condensate TP (mg/L)	Condensate TP (lbs/hr)	Product TP (mg/kg wet)	Product TP (lbs/hr)	Overall TP Accounted (%)
9/2/97		20.0	3.4	63.9	3.5	21.1	1,558	89	60	149	364	338	16.4	27.1	295	3,019	30.3	1,385	14.6	45	3.4	21,167	9.8	91.8	1,102	11.0	109	1.2	7	0.5	14,800	6.8	76.8
9/3/97		25.0	3.2	49.1	4.0	26.2	1,544	89	60	149	342	395	20.2	25.5	350																		
9/4/97		25.0	3.1	50.7	4.0	26.2	2,094	89	58	147	334	390	27.5	24.6	338																		
9/5/97		25.0	2.7	57.0	4.0	26.6	5,816	89	58	147	370	338	77.4	27.2	233																		
9/6/97		25.0	3.5	50.4	4.0	25.9	5,200	89	58	147	338	435	67.4	24.9	343																		
9/8/97		25.0	3.1	46.7	4.0	26.2	2,170	89	56	145	322	387	28.5	23.4	335	3,310	41.5	1,603	21.1	47	3.4	24,394	17.5	101.1	760	9.5	178	2.3	6	0.4	10,600	7.6	108.8
9/10/97		25.0	2.8	67.1	4.0	26.5	1,770	90	56	146	324	355	23.4	23.7	308																		
9/15/97		20.0	3.0	55.7	4.2	22.1	1,630	90	56	146	322	301	18.0	23.5	260	3,269	32.8	1,457	16.1	43	3.1	23,422	10.9	92.1	850	8.5	162	1.8	5	0.3	14,900	6.9	106.5
10/21/97		20.0	3.5	77.8	4.0	21.5	2,810	92	56	148	374	354	30.2	27.7	296	3,175	31.8	3,175	34.2	47	3.4	17,732	6.8	139.4	1,060	10.6	120	1.3	4	0.3	16,120	6.1	73.0
10/22/97		16.0	3.6	84.2	4.1	18.0	2,034	88	56	144	382	291	18.3	27.5	246	3,395	27.2	1,572	14.2	50	3.6	17,226	5.0	83.9	1,030	8.3	124	1.1	4	0.3	14,980	4.4	70.1
10/30/97		20.0	3.3	62.5	3.0	20.6	1,652	92	53	145	272	332	17.1	19.7	295	3,206	32.1	1,759	18.2	38	2.7	15,407	7.3	87.7	800	8.0	131	1.4	2	0.1	15,760	7.4	111.4
1/12/98		25.0	2.9	68.4	3.5	25.9	1,646	89	54	143	287	362	21.3	20.5	320	3,144	39.4	1,707	22.2	52	3.7				930	11.6	116	1.5	5	0.4	9,700	4.5	55.2
1/13/98		30.0			4.2			89	54	143																							
1/15/98		25.0	2.9	63.8	2.5	24.9	2,399	90	56	146	231	364	29.9	16.9	317	3,373	42.3	1,895	23.6	39	2.8	22,434	11.2	89.0	860	10.8	125	1.6	3	0.2	11,640	5.8	70.5
1/16/98		24.0	2.8		2.5	24.1	1,537	88	53	141	298	341	18.5	21.0	302	3,081	37.1	1,426	17.2	38	2.7	29,981			862	10.4	127	1.5	4	0.3	11,460		
1/19/98		24.0	2.8	58.9	4.0	25.6	2,024	87	52	139	250	331	26.0	17.4	288	3,144	37.8	1,482	19.0	35	2.5	35,654	17.4	103.0	1,160	13.9	88	1.1	4	0.3	6,300	3.1	32.0
1/20/98		23.0	2.7	71.3	3.0	23.8	3,123	86	52	138	289	313	37.1	20.0	256	3,206	36.9	1,738	20.7	36	2.5	43,722	15.7	105.2	870	10.0	120	1.4	3	0.2	9,660	3.5	51.2
1/21/98		20.0	2.7	69.4	2.5	20.6	1,474	84	52	136	331	269	15.2	22.5	232	3,269	32.8	1,667	17.2	50	3.4	43,410	14.5	107.0	930	9.3	170	1.8	2	0.2	14,200	4.7	71.4
1/23/98	X	25.0	2.9	59.0	3.5	25.9	2,714	86	52	138	194	365	35.2	13.4	317																		
1/26/98	X	20.0	2.9	54.9	2.5	20.5		85	49	134	229	287		15.4	272																		
1/27/98	X	19.0	2.9	57.8	2.5	19.5	1,279	85	49	134	267	275	12.5	17.9	244	3,206	30.5	1,936	19.0	35	2.3	34,926	14.8	118.1	1,226	11.7	98	1.0	2	0.1	10,700	4.5	48.1
1/28/98	X	19.0	2.9	61.3	2.5	19.5	1,240	82	49	131	231	276	12.1	15.1	248	3,081	29.3	1,957	19.2	36	2.3	31,334	12.7	116.6	1,662	15.8	97	0.9	2	0.2	12,600	5.1	39.3
1/29/98	X	20.0	2.8	65.0	2.5	20.5	1,333	82	49	131	266	284	13.7	17.4	253	3,123	31.3	1,645	16.9	35	2.3	31,542	12.3	100.6	1,120	11.2	104	1.1	2	0.2	11,220	4.4	49.9
1/30/98	X	36.8	2.8	58.7	3.6	36.7	1,439	82	49	131	271	523	26.4	17.8	479	3,432	63.3	1,586	29.1	34	2.3	27,743	22.6	85.4	1,042	19.2	90	1.7	2	0.1	9,700	7.9	50.6
2/2/98	X	20.0	2.7	66.3	2.5	20.6	1,570	84	52	136	270	270	16.2	18.4	236	3,109	31.2	1,662	17.1	44	3.0	33,806	12.0	103.3	1,156	11.6	92	0.9	3	0.2	7,600	2.7	33.0
2/3/98	X	20.0	2.9	64.2	2.5	20.5	1,710	83	51	134	274	287	17.5	18.4	251	3,827	38.4	1,662	17.0	32	2.2	38,829	15.2	89.7	924	9.3	94	1.0	2	0.2	15,060	5.9	75.8
2/4/98	X	20.0	2.9	63.0	2.5	20.4	1,644	84	51	135	269	290	16.8	18.2	255	3,598	36.1	3,140	32.1	39	2.6	29,669	12.0	129.8	898	9.0	95	1.0	3	0.2	13,960	5.7	75.8
2/5/98	X	23.0	2.9	58.1	2.9	23.5	1,716	84	51	135	302	334	20.2	20.4	293	4,480	51.6	1,648	19.4	37	2.5	32,792	16.6	74.5	910	10.5	112	1.3	3	0.2	13,420	6.8	79.1
2/6/98	X	20.0	2.9	63.2	2.5	20.5	1,610	84	52	136	324	285	16.5	22.0	247	3,234	32.4	1,706	17.5	39	2.7	38,049	14.8	108.0	924	9.3	102	1.0	3	0.2	16,220	6.3	82.1
2/9/98		20.0			2.5			86	54	140																							
2/12/98	X	30.0			3.7			87	55	142																							
2/13/98	X	30.0	2.8	72.5	3.7	30.7	1,472	87	54	141	300	419	22.6	21.2	375	2,850	42.8	1,498	23.1	39	2.7	26,363	13.6	92.1	736	11.1	97	1.5	2	0.2	12,180	6.3	71.9
2/17/98	X	30.0	2.6	58.7	4.0	31.3	1,944	86	54	140	365	384	30.4	25.6	328	2,684	40.3	1,666	26.1	39	2.7	22,121	12.4	102.1	818	12.3	113	1.8	3	0.2	9,800	5.5	60.5
2/18/98	X	30.0	2.6	53.2	4.0	31.3	1,360	85	54	139	306	384	21.3	21.3	342	2,707	40.7	1,332	20.9	37	2.5	24,593	15.8	96.3	730	11.0	94	1.5	3	0.2	10,900	7.0	78.8
2/19/98	X	30.0			4.0			85	54	139																							
2/20/98	X	30.0			4.0			85	56	141																							
2/23/98	X	30.0	3.1	60.1	4.0	30.7	1,781	87	56	143	329	458	27.4	23.5	407	3,432	51.6	1,586	24.4	39	2.8	33,312	22.5	96.4	940	14.1	112	1.7	2	0.1	13,000	8.8	75.3
2/24/98	X	30.0	2.9	57.54	4.0	30.9	1,588	86	56	142	295	428	24.6	21.0	382	3,310	49.8	1,780	27.6	40	2.8	33,312	22.1	105.7	1,016	15.3	116	1.8	2	0.1	12,500	8.3	67.1
2/25/98	X	30.0	2.7	59.15	3.8	30.8	1,576	86	56	142	295	408	24.3	21.0	363	3,109	46.7	1,778	27.5	39	2.8	37,268	22.9	113.6	960	14.4	116	1.8	2	0.2	14,200	8.7	73.9
2/27/98	X	30.0	2.9	54.82	3.6	30.5		86	55	141	300	441		21.2	420	3,785	56.9			27	1.9	31,334	24.0		1,162	17.5			2	0.1	15,240	11.7	67.7
3/2/98	X	30.0	2.8	52.82	4.0	31.0	1,729	87	57		261	419	26.8		392	3,175	47.7	1,634	25.4	27		24,958	18.5	92.0	920	13.8	113	1.8	1		6,960	5.2	50.0
3/3/98	X	30.0	2.9	57.25	3.8	30.7	1,680	87	57		322	432	25.8		407	3,300	49.6	1,541	23.7	39		32,531	23.1	94.4	858	12.9	97	1.5	1		11,960	8.5	77.4
3/5/98	X	30.0	2.9	57.18	3.8	30.7	1,634	87	59		319	435	25.1		410	3,269	49.1	1,666	25.6	39		29,798	21.4	95.6	810	12.2	98	1.5	1		13,900	10.0	94.3
3/6/98	X	30.0	3.0	64.89	3.9	30.7	1,600	85	58		269	443	24.6		418	3,873	58.2	1,707	26.3	40		29,512	19.0		1,300	19.5	118	1.8	2		11,780	7.6	48.2
3/7/98	X	30.0		64.13	3.9			85	58													30,397									12,260		
3/8/98	X	30.0		63.97	3.9			84	56													30,761									11,220		
3/10/98	X	30.0	3.0	52.56	3.9	30.7	1,656	85	58		816	447	25.4		422	3,331	50.1	1,619	24.9	36		28,419	22.8	95.3									
3/11/98		22.0		73.23	3.9			86	58													32,948											

Notes

A - Steady-state operation defined by a minimum of 10 hours of daily operation with no "logged" processing issues

B - assumed 28 %TS on mechanical side of centrifuge (dewatering trial data available) and ignored solids fraction of polymer feed

C - value is the sum of the flows through packed tower and venturi scrubbers

D - assumed C3 water total solids content of 10 mg/L (from previous lab results)

Table B-4: Product Hauling

Haul Date	Trailers	Wet Tons	Destination	Comments
16-May-97	110	7.71		Centridry Product
12-Jun-97	10	9.23	GroCo	Centridry Product
25-Jun-97	109	11.66	Boulder Park	Centridry Product
23-Jul-97 (est.)	109	8.52	Boulder Park	Centridry Product
23-Jul-97 (est.)	110	17.95	Boulder Park	Centridry Product
21-Aug-97	109	10.01	Green Valley	Centridry Product
4-Sep-97	111	11.38	Boulder Park	Centridry Product
4-Sep-97	110	12.91	Boulder Park	Centridry Product
5-Sep-97	111/110	21.87	Boulder Park	Centridry Product
25-Sep-97	109	13.06	Boulder Park	Centridry Product- w/ticket # 11961
25-Sep-97	110	6.50	Boulder Park	Centridry Product-est. per BMP
25-Sep-97	93/33	29.63	Boulder Park	Centridry Product + 10% dig #5 dewatered
26-Oct-97	109	10.76	Boulder Park	Centridry Product
12-Nov-97	110	11.34	Boulder Park	Centridry Product
12-Nov-97	109	4.48	Boulder Park	Centridry Product
17-Dec-97	109	6.24	Boulder Park	Centridry Product
25-Nov-97	60/10	30.27	Weyerhaeuser	3.7 tons Centripress Product + Centridry Product
26-Nov-97	102/86	27.82	Weyerhaeuser	1.67 tons Centripress Product +Centridry Product
10-Jan-98	110	7.40	Boulder Park	Centridry Product
10-Jan-98	109	8.72	Boulder Park	Centridry Product
17-Jan-98	109	8.20	Boulder Park	Centridry Product
17-Jan-98	110	8.91	Boulder Park	Centridry Product
20-Jan-98	113	10.67	Weyerhaeuser	Centridry Product
23-Jan-98	110	6.82	Weyerhaeuser	Centridry Product
23-Jan-98	109	7.57	Weyerhaeuser	Centridry Product
28-Jan-98	113	9.02	Weyerhaeuser	Centridry Product
28-Jan-98	109	7.64	Weyerhaeuser	Centridry Product
29-Jan-98	110	6.37	Weyerhaeuser	Centridry Product
31-Jan-98	109	9.97	Weyerhaeuser	Centridry Product
10-Feb-98	113	8.54	Weyerhaeuser	Centridry Product
10-Feb-98	109	8.73	Weyerhaeuser	Centridry Product
14-Feb-98	110	8.29	Boulder Park	Centridry Product
14-Feb-98	109	9.56	Boulder Park	Centridry Product
23-Feb-98	113	11.18	Green Valley	Centridry Product
23-Feb-98	110	10.61	Green Valley	Centridry Product
27-Feb-98	109	9.29	Weyerhaeuser	Mixing Study (Hauled on ticket 12895)
27-Feb-98	110	8.91	Weyerhaeuser	Mixing Study (Hauled on ticket 12895)
3-Mar-98	113	9.64	LRI	Compost Study (Centridry Product)
27-Feb-98	62/63		Weyerhaeuser	Mixing Study (17.08 tons of Dewatered Cake & Centridry Product)
27-Feb-98	91/31		Weyerhaeuser	Mixing Study (29.63 tons of Dewatered Cake & Centridry Product)
27-Feb-98	91/31	28.51	Weyerhaeuser	Mixing Study (Represents Centridry Portion Used in Mixing Study)
3-Mar-98	109	10.13	LRI	Compost Study - Full Scale Trial (Centridry Product)
3-Mar-98	63	8.99	LRI	Compost Study - Full Scale Trial (Centridry Product)
9-Mar-98	110	10.19	GroCo	Compost Study - Full Scale Trial (Centridry Product)
9-Mar-98	113	9.52	GroCo	Compost Study - Full Scale Trial (Centridry Product)
9-Mar-98	114	10.49	GroCo	Compost Study - Full Scale Trial (Centridry Product)
9-Mar-98	109	10.05	GroCo	Compost Study - Full Scale Trial (Centridry Product)
20-Mar-98	110	10.30	Boulder Park	Centridry Product
20-Mar-98	109	5.54	Boulder Park	Centridry Product
17-Jul-98		9.75	LRI	Compost Study - Full Scale Trial (Centridry Product)
Overall Total =		540.85		
Demonstration Total =		441.73		

Table B-5: Centridry Product Quality (Conventionals)

Date	Steady State [A]	pH	TS (%)	TVS (%)	NH_4-N (mg/kg wet)	NH_4-N (mg/kg dry)	TKN (mg/kg wet)	TKN (mg/kg dry)	Org - N (mg/kg dry)	TP (mg/kg wet)	TP (mg/kg dry)	Ortho-P (mg/kg wet)
9/2/97		8.72	63.91	62.47	4,085	6,392	21,167	33,120	26,728	14,800	23,158	
9/3/97		8.60	49.12	65.30								
9/4/97		8.61	50.72	66.05								
9/5/97		8.43	56.96	60.50								
9/6/97		8.67	50.40	61.38								
9/8/97		8.52	46.71	66.01	3,730	7,985	24,394	52,224	44,239	10,600	22,693	
9/10/97		8.50	67.14	66.07								
9/15/97		8.54	55.70	65.90	3,805	6,831	23,422	42,050	35,219	14,900	26,750	
10/21/97		8.34	77.78	57.18	4,655	5,985	17,732	22,798	16,813	16,120	20,725	
10/22/97		8.13	84.23	58.19	4,690	5,568	17,226	20,451	14,883	14,980	17,785	
10/30/97		8.30	62.53	61.97	3,940	6,301	15,407	24,639	18,338	15,760	25,204	
1/12/98		8.72	68.35	55.69	4,690	6,862				9,700	14,192	1,340
1/15/98		8.56	63.81	58.05	4,910	7,695	22,434	35,157	27,463	11,640	18,242	1,410
1/17/98		8.45	56.89	58.63	4,170	7,330	29,981	52,700	45,370	11,460	20,144	905
1/19/98		8.53	68.91	55.94	4,390	6,371	35,654	51,740	45,369	6,300	9,142	850
1/20/98		8.49	71.30	60.74	4,520	6,339	43,722	61,321	54,982	9,660	13,548	850
1/21/98		8.50	69.35	62.00	4,620	6,662	43,410	62,596	55,934	14,200	20,476	1,435
1/23/98	X	8.53	58.96	60.88	4,485	7,607						1,295
1/26/98	X	8.54	54.93	60.83	4,725	8,602						1,460
1/27/98	X	8.51	57.78	59.50	4,230	7,321	34,926	60,447	53,126	10,700	18,519	1,175
1/28/98	X	8.59	61.28	61.09	4,388	7,161	31,334	51,133	43,972	12,600	20,561	1,280
1/29/98	X	8.60	64.97	55.67	4,760	7,326	31,542	48,549	41,222	11,220	17,270	1,480
1/30/98	X	8.56	58.67	58.66	4,290	7,312	27,743	47,287	39,974	9,700	16,533	940
2/2/98	X	8.60	66.30	60.88	4,585	6,916	33,806	50,989	44,074	7,660	11,554	805
2/3/98	X	8.60	64.17	59.07	4,388	6,838	38,829	60,510	53,671	15,060	23,469	570
2/4/98	X	8.74	63.02	60.78	4,585	7,275	29,669	47,079	39,803	13,960	22,152	680
2/5/98	X	8.65	58.05	60.54	4,230	7,287	32,792	56,489	49,202	13,420	23,118	675
2/6/98	X	8.55	63.22	60.58	4,485	7,094	38,049	60,185	53,091	16,220	25,656	1050
2/13/98	X	8.61	72.48	80.95	4,355	6,009	26,363	36,373	30,364	12,180	16,805	595
2/17/98	X	8.59	58.68	59.02	3,883	6,617	22,121	37,698	31,080	9,800	16,701	860
2/18/98	X	8.61	53.21	60.25	3,995	7,508	24,593	46,219	38,711	10,900	20,485	995
2/23/98	X	8.68	60.13	61.98	4,585	7,625	33,312	55,400	47,775	13,000	21,620	1,015
2/24/98	X	8.53	57.54	60.49	3,995	6,943	33,312	57,894	50,951	12,500	21,724	955
2/25/98	X	8.43	59.15	60.19	3,968	6,708	37,268	63,006	56,298	14,200	24,007	595
2/27/98	X	8.49	54.82	57.15	4,620	8,428	31,334	57,158	48,730	15,240	27,800	600
3/2/98	X	8.56	52.82	61.32	4,680	8,860	24,958	47,251	38,391	6,960	13,177	1385
3/3/98	X	8.51	57.25	62.59	4,140	7,231	32,531	56,823	49,591	11,960	20,891	1155
3/5/98	X	8.51	57.18	60.35	4,485	7,844	29,798	52,113	44,269	13,900	24,309	835
3/6/98	X	8.46	64.89	62.01	4,910	7,567	29,512	45,480	37,913	11,780	18,154	1040
3/7/98	X	8.47	64.13	62.56	4,620	7,204	30,397	47,399	40,195	12,260	19,117	
3/8/98	X	8.50	63.97	62.14	4,550	7,113	30,761	48,087	40,974	11,220	17,539	
3/10/98	X	8.46	52.56	62.81	4,140	7,877	28,419	54,070	46,193			1330
3/11/98		7.68	73.23	58.46	4,872	6,653	32,948	44,992	38,339			
3/16/98		8.04	59.53	56.51	4,290	7,206	30,189	50,712	43,506			1200
undigested												
3/23/98		7.01	45.55	52.40	1,770	3,886	15,042	33,023	29,137			2,615

Data Summary	pH	TS (%)	TVS (%)	NH_4-N (mg/kg)	NH_4-N (mg/kg dry)	TKN (mg/kg)	TKN (mg/kg dry)	Org - N (mg/kg dry)	TP (mg/kg)	TP (mg/kg dry)	Ortho-P (mg/kg)
(Overall)											
average	**8.45**	**61.29**	**61.12**		**7,140**		**48,393**	**41,299**		**19,801**	**1,025**
maximum	**8.74**	**84.23**	**80.95**		**8,860**		**63,006**	**56,298**		**27,800**	**1,480**
minimum	**7.68**	**46.71**	**55.67**		**5,568**		**20,451**	**14,883**		**9,142**	**570**
(Steady-state)											
average	**8.55**	**60.01**	**61.29**		**7,371**		**51,636**	**44,329**		**20,053**	**990**
maximum	**8.74**	**72.48**	**80.95**		**8,860**		**63,006**	**56,298**		**27,800**	**1,480**
minimum	**8.43**	**52.56**	**55.67**		**6,009**		**36,373**	**30,364**		**11,554**	**570**

Notes:

A - Steady-state operation defined by a minimum of 10 hours of daily operation with no logged processing issues

Table B-6: Centridry Product Quality (Metals / Micro)

Date	Steady State[A]	Potassium (mg/kg dry)	Arsenic (mg/kg dry)	Cadmium (mg/kg dry)	Chromium (mg/kg dry)	Copper (mg/kg dry)	Lead (mg/kg dry)	Magnesium (mg/kg dry)	Manganese (mg/kg dry)	Mercury (mg/kg dry)	Molybdenum (mg/kg dry)	Nickel (mg/kg dry)	Selenium (mg/kg dry)	Silver (mg/kg dry)	Zinc (mg/kg dry)	Salmonellae (MPN/100g dry)	Fecal Coliform (MPN/100g dry)
9/2/97		1,870	8.2	7.5	49.8	792	67.3	5830	682	2.3	14.3	21.5	6.6	44.1	751		
9/15/97		1,940	7.5	10.2	45.0	744	65.8	5770	680	2.4	13.5	20.6	6.0	43.2	727	< 3	15,000
1/12/98		1,720	9.5	8.5	50.4	820	68.8	4080		2.5	13.2	28.9	6.9	44.3	740	< 3	210
1/19/98		1,690	10.8	8.2	47.7	789	67.9	4230		2.7	12.1	27.6	6.7	42.2	701	< 3	29
1/26/98	X	1,550	8.8	7.3	43.4	709	61.1	4140		2.2	11.7	25.5	6.3	38.5	619	< 3	120
2/2/98	X	1,690	10.2	8.1	53.6	788	67.9	4330		2.7	12.6	31.6	7.7	41.6	657	< 3	4,700
2/23/98	X	1,680	9.0	8.2	48.4	815	64.9			2.9	12.7	26.5	6.6		649	< 3	1,200
3/2/98	X	1,790	8.4	8.1	50.5	839	72.5			2.8	13.3	36.0	5.9		663	< 4	620
3/16/98		2,050	8.8	7.7	53.2	857	70.1	4540	1110	2.7	13.4	35.3	7.8	46.8	657	< 3	510
(undigested) 3/23/98		2,660	3.9	2.6	29.0	299	42.6	30700	1190	3.3	5.9	18.2	2.6 (<RDL)	19.0	299	4.3	> 300,000

Data Summary	Potassium (mg/kg dry)	Arsenic (mg/kg dry)	Cadmium (mg/kg dry)	Chromium (mg/kg dry)	Copper (mg/kg dry)	Lead (mg/kg dry)	Magnesium (mg/kg dry)	Manganese (mg/kg dry)	Mercury (mg/kg dry)	Molybdenum (mg/kg dry)	Nickel (mg/kg dry)	Selenium (mg/kg dry)	Silver (mg/kg dry)	Zinc (mg/kg dry)	Salmonellae (MPN/100g dry)	Fecal Coliform (MPN/100g dry)
(Overall)																
average	**1,776**	**9.0**	**8.2**	**49.1**	**795**	**67.4**	**4,703**	**824**	**2.6**	**13.0**	**28.2**	**6.7**	**43.0**	**685**	**< 3**	**611**
maximum	**2,050**	**10.8**	**10.2**	**53.6**	**857**	**72.5**	**5,830**	**1,110**	**2.9**	**14.3**	**36.0**	**7.8**	**46.8**	**751**		**15,000**
minimum	**1,550**	**7.5**	**7.3**	**43.4**	**709**	**61.1**	**4,080**	**680**	**2.2**	**11.7**	**20.6**	**5.9**	**38.5**	**619**		**29**
(Steady-state)																
average	**1,678**	**9.1**	**7.9**	**49.0**	**788**	**66.6**	**4,235**		**2.7**	**12.6**	**29.9**	**6.6**	**40.1**	**647**	**< 3**	**805**
maximum	**1,790**	**10.2**	**8.2**	**53.6**	**839**	**72.5**	**4,330**		**2.9**	**13.3**	**36.0**	**7.7**	**41.6**	**663**		**4,700**
minimum	**1,550**	**8.4**	**7.3**	**43.4**	**709**	**61.1**	**4,140**		**2.2**	**11.7**	**25.5**	**5.9**	**38.5**	**619**		**120**

Notes:

A - Steady-state operation defined by a minimum of 10 hours of daily operation with no logged processing issues

Table B-7: Summary of Results-Methods 3A, 6C, 7E, 10 and 25A, Am Test - Air Quality, LLC

File Name: JAA\98-018WD\GASSM
Client: King County Environmental Lab
Location: Renton, Washington

				CENTRIDRY[R] SCRUBBER EXHAUST					
	Run #1	Run #2	Run #3	Run #1	Run #2	Run #3	Run #4	Run #5	Run #6
Date:	10/21/97	10/29/97	10/29/97	2/4/98	2/4/98	2/4/98	2/5/98	2/5/98	2/5/98
Start Time:	0932	1028	1156	1000	1146	1325	0853	1101	1232
Stop Time:	1031	1127	1255	1101	1245	1424	0953	1200	1331
Sample Length (minutes):	60	60	60	60	60	60	60	60	60
Solids Flow (gpm):	20	20	20	20	20	20	20	35	45
Polymer Flow (gpm):	4	4	4	2.5	2.5	2.5	2.5	4.30	5.6
Burner Setpoint (^oC):	210	200	200	160	170	180	160	185	205
Oxygen (percent):	13.8	11.7	11.8	16.6	15.9	15.4	16.3	13.0	11.2
Measured Airflow (dscf/min.):	494.8	484.6	484.3	660.2	616.6	640.7	621.7	625.1	658.0
Moisture (Bws):	0.0225	0.0238	0.0243	0.0187	0.0192	0.0196	0.0192	0.0214	0.0208
METHOD 6C - SULFUR DIOXIDE (SO_2)									
Sulfur Dioxide Emission Conc. (ppm):	1.5	0.5 *	1.1	0.9	0.1 *	0.6	0.4 *	< 0.5 *	0.5 *
Sulfur Dioxide Emission Rate (lb/hr):	0.007	0.002	0.005	0.006	0.001	0.004	0.002	< 0.003	0.003
METHOD 7E - NITROGEN OXIDES (NOx)									
Nitrogen Oxides Emission Conc. (ppm):	13.6	12.5	10.4	12.4	14.2	14.4	13.6	15.5	23.6
Nitrogen Oxides Emission Rate (lb/hr):	0.048	0.043	0.036	0.059	0.063	0.066	0.061	0.069	0.111
METHOD 10 - CARBON MONOXIDE (CO)									
Carbon Monoxide Emission Conc. (ppm):	324.2	87.0	243.7	28.7	29.4	34.4	26.0	61.7	101.3
Carbon Monoxide Emission Rate (lb/hr):	0.700	0.184	0.515	0.083	0.079	0.096	0.071	0.168	0.291
METHOD 25A - TOTAL HYDROCARBONS (THC)									
Total Hydrocarbon Emission Conc. (ppm, wet):	112.7	106.8	148.3	82.1	88.2	88.4	79.0	109.4	122.8
Total Hydrocarbon Emission Conc. (ppm, dry):	115.3	109.4	152.0	83.7	89.9	90.2	80.5	111.8	125.4
Total Hydrocarbon Emission Rate (lb/hr):	0.392	0.364	0.505	0.379	0.381	0.397	0.344	0.480	0.567

* The SO_2 analyzer sensitivity and accuracy is + 0.5 ppm SO_2, which for this test program is 0.5% of a 0-100 ppm scale. The SO_2 analyzer actually has a readability of 0.01 ppm, therefore, some of the readings may be less than the sensitivity and accuracy of the instrument.

Table B-8: Summary of Results-Methods 1,2,3A,4 and PSAPCA 5, Am Test - Air Quality, LLC

File Name: JAA\98-018WD\M5BH\SUM
Client: King County Environmental Lab
Location: Renton, Washington

				CENTRIDRY" SCRUBBER EXHAUST					
	RUN #1	RUN #2	RUN #3	RUN #1	RUN #2	RUN #3	RUN #4	RUN #5	RUN #6
Lab #:	2206	2207	2208	2625	2626	2627	2628	2629	2630
Date:	10/21/97	10/29/97	10/29/97	2/4/98	2/4/98	2/4/98	2/5/98	2/5/98	2/5/98
Start Time:	0943	0936	1100	0955	1147	1320	0850	1100	1230
Stop Time:	1043	1036	1200	1055	1247	1420	0950	1200	1330
Sample Length (minutes):	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Solids Flow (gpm):	20	20	20	20	20	20	20	35	45
Polymer Flow (gpm):	4	4	4	2.5	2.5	2.5	2.5	4.3	5.6
Burner Setpoint (°C):	210	200	200	160	170	180	160	185	205
Volume Sampled (ft³):	46.125	47.968	48.243	56.753	55.715	55.709	56.343	59.276	58.001
Volume Sampled (dscf):	46.892	47.112	46.958	54.811	53.585	55.730	54.489	57.871	56.382
Volume Sampled (dscm):	1.328	1.334	1.330	1.552	1.518	1.578	1.543	1.639	1.597
Stack Gas Moisture (%):	2.25	2.38	2.43	1.87	1.92	1.96	1.92	2.14	2.08
Barometric Pressure ("Hg):	30.30	29.85	29.85	29.60	29.60	29.60	29.80	29.85	29.85
Static Pressure ("H_2O)	-0.004	-0.03	-0.018	-0.012	-0.012	-0.014	-0.012	-0.012	-0.015
Stack Pressure ("Hg):	30.30	29.85	29.85	29.60	29.60	29.60	29.80	29.85	29.85
Stack Temperature (°F):	63.0	63.0	64.0	56.0	57.0	57.0	57.0	58.0	58.0
Stack Temperature (°R):	523.0	523.0	524.0	516.0	517.0	517.0	517.0	518.0	518.0
Average Conc. CO_2 (%):	4.5	5.8	5.8	3.0	3.5	3.8	3.2	5.4	6.6
Average Conc. O_2 (%):	13.8	11.7	11.8	16.6	15.9	15.4	16.3	13.0	11.2
Molecular Weight (dry, g/g-mole):	29.27	29.40	29.40	29.14	29.20	29.22	29.16	29.38	29.50
Molecular Weight (wet, g/g-mole):	29.02	29.12	29.12	28.94	28.98	29.00	28.95	29.14	29.26
Average Velocity Head ("H_2O):	0.032	0.031	0.031	0.053	0.050	0.054	0.051	0.058	0.055
Pitot Tube C_p:	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Stack Gas Velocity (ft/sec):	9.68	9.64	9.65	13.0	12.2	12.7	12.2	12.3	12.9
Stack Diameter (inches):	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Stack Area (ft²):	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Stack Gas Airflow (dscf/min.):	494.8	484.6	484.3	660.2	616.6	640.7	621.7	625.1	658.0
Stack Gas Airflow (acf/min):	495.1	492.9	493.6	665.0	622.1	647.0	623.2	629.2	660.8
Nozzle Diameter (inches):	0.504	0.504	0.504	0.470	0.470	0.470	0.470	0.470	0.470
Isokinetics (%):	95	98	98	99	100	100	100	101	101
Front-half Particulate Matter Emission Conc. (gr/dscf):	0.019	0.001	0.010	0.002	0.001	0.002	0.0004	0.001	0.002
Back-half Particulate Matter Emission Conc. (gr/dscf):	0.010	0.010	0.009	0.001	0.001	0.001	0.001	0.002	0.002
Total Particulate Matter Emission Conc. (gr/dscf):	0.029	0.011	0.019	0.003	0.002	0.003	0.002	0.003	0.004
Total Particulate Matter Emission Conc. (mg/dscm):	66.8	24.9	42.9	5.81	4.69	7.07	3.97	7.96	8.72
Total Particulate Matter Emission Rate (lb/hr):	0.124	0.045	0.078	0.014	0.011	0.017	0.009	0.019	0.021

Table B-9: Summary of Results - Moisture and Airflow, Am Test - Air Quality, LLC

File Name: CLR\98-018WD\M5BH\SUM
Client: King County Environmental Lab
Location: Renton, Washington

				CENTRIDRY SCRUBBER EXHAUST					
	RUN #1	RUN #2	RUN #3	RUN #1	RUN #2	RUN #3	RUN #4	RUN #5	RUN #6
Lab #:	2206	2207	2208	2625	2626	2627	2628	2629	2630
Date:	10/21/97	10/29/97	10/29/97	2/4/98	2/4/98	2/4/98	2/5/98	2/5/98	2/5/98
Start Time:	0943	0936	1100	0955	1147	1320	0850	1100	1230
Stop Time:	1043	1036	1200	1055	1247	1420	0950	1200	1330
Sample Length (minutes):	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Solids Flow (gpm):	20	20	20	20	20	20	20	30	40
Polymer Flow (gpm):	4	4	4	2.5	2.5	2.5	2.5	3.75	5.0
Burner Setpoint (°C)	210	200	200	160	170	180	160	55% TS prod	55% TS prod
Volume Sampled (ft^3):	46.125	47.968	48.243	56.753	55.715	55.709	56.343	59.276	58.001
Volume Sampled (dscf):	46.892	47.112	46.958	54.811	53.585	55.730	54.489	57.871	56.382
Volume Sampled (dscm):	1.328	1.334	1.330	1.552	1.518	1.578	1.543	1.639	1.597
Stack Gas Moisture (%):	2.25	2.38	2.43	1.87	1.92	1.96	1.92	2.14	2.08
Barometric Pressure ("Hg):	30.30	29.85	29.85	29.60	29.60	29.60	29.80	29.85	29.85
Static Pressure ("H_2O)	-0.004	-0.03	-0.018	-0.012	-0.012	-0.014	-0.012	-0.012	-0.015
Stack Pressure ("Hg):	30.30	29.85	29.85	29.60	29.60	29.60	29.80	29.85	29.85
Stack Temperature (°F):	63.0	63.0	64.0	56.0	57.0	57.0	57.0	58.0	58.0
Stack Temperature (°R):	523.0	523.0	524.0	516.0	517.0	517.0	517.0	518.0	518.0
Average Conc. CO_2 (%):	4.5	5.8	5.8	3.0	3.5	3.8	3.2	5.4	6.6
Average Conc. O_2 (%):	13.8	11.7	11.8	16.6	15.9	15.4	16.3	13.0	11.2
Molecular Weight (dry, g/g-mole):	29.27	29.40	29.40	29.14	29.20	29.22	29.16	29.38	29.50
Molecular Weight (wet, g/g-mole):	29.02	29.12	29.12	28.94	28.98	29.00	28.95	29.14	29.26
Average Velocity Head ("H_2O):	0.032	0.031	0.031	0.053	0.050	0.054	0.051	0.058	0.055
Pitot Tube C_p:	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Stack Gas Velocity (ft/sec):	9.91	9.81	9.82	13.0	12.2	12.7	12.2	12.3	12.9
Stack Diameter (inches):	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Stack Area (ft^2):	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Stack Gas Airflow (dscf/min.):	506.3	493.0	492.3	660.2	616.6	640.7	621.7	625.1	658.0
Stack Gas Airflow (acf/min):	506.6	501.5	501.9	665.0	622.1	647.0	623.2	629.2	660.8
Nozzle Diameter (inches):	0.504	0.504	0.504	0.470	0.470	0.470	0.470	0.470	0.470
Isokinetics (%):	95	98	98	99	100	100	100	101	101
Front-half Particulate Matter Emission Conc. (gr/dscf):	0.019	0.001	0.010	0.002	0.001	0.002	0.0004	0.001	0.002
Back-half Particulate Matter Emission Conc. (gr/dscf):	0.010	0.010	0.009	0.001	0.001	0.001	0.001	0.002	0.002
Total Particulate Matter Emission Conc. (gr/dscf):	0.029	0.011	0.019	0.003	0.002	0.003	0.002	0.003	0.004
Total Particulate Matter Emission Conc. (mg/dscf):	66.8	24.9	42.9	5.81	4.69	7.07	3.97	7.96	8.72
Total Particulate Matter Emission Rate (lb/hr):	0.127	0.046	0.079	0.014	0.011	0.017	0.009	0.019	0.021

Table B-10: Summary of Emission Concentration Results, TO-14 Volatile Organic Compounds, Am Test - Air Quality, LLC

File Name: JAA\98-018WD\TO14\CSUM
Client: King County Environmental Lab
Location: Renton, Washington

	CENTRIDRY^{R} SCRUBBER STACK					
	RUN #1	RUN #2	RUN #1	RUN #2	RUN #5	RUN #6
Lab Number:	2207, 01A	2213, 01A	2620, 01A	2621, 02A	2622, 03A	2623, 04A
Date:	10/21/97	10/29/97	2/4/98	2/4/98	2/5/98	2/5/98
Start Time:	1000	1030	0955	1147	1100	1230
Stop Time:	1100	1130	1055	1247	1200	1330
Solids Flow (gpm):	20	20	20	20	35	45
Polymer Flow (gpm):	4	4	2.5	2.5	4.3	5.6
Burner Setpoint (^{o}C):	210	200	160	170	185	205
Analyte	μg/m^3	μg/m^3	μg/m^3	μg/m^3	μg/m^3	μg/m^3
Dichlorodifluoromethane	34 U	8.4 U	7.1 U	5.6 U	10 U	7.3 U
Chloromethane	63 B	340	3.0 U	2.4 U	4.2 U	3.1 U
1,2-Dichloro-1,1,2,2-tetrafluoroethane	48 U	12 U	10 U	8.0 U	14 U	10 U
Vinyl chloride	17 U	4.4 U	3.7 U	2.9 U	5.2 U	3.8 U
Bromomethane	26 U	47	5.6 U	4.4 U	7.9 U	5.8 U
Chloroethane	18 U	15 B	3.8 U	3.0 U	5.4 U	3.9 U
Trichlorofluoromethane	38 U	9.6 U	8.1 U	6.4 U	11 U	8.3 U
1,1-Dichloroethene	27 U	6.8 U	5.7 U	4.5 U	8.0 U	5.9 U
Methylene Chloride	99 B	5.9 U	110	95	100	56
1,1,2-Trichloro-1,2,2-trifluoroethane	52 U	13 U	11 U	8.7 U	16 U	11 U
1,1-Dichloroethane	28 U	6.9 U	5.8 U	4.6 U	8.2 U	6.0 U
cis-1,2-Dichloroethene	56 B	6.8 U	19 B	4.5 U	68	5.9 U
Chloroform	69 B	44	81	69	58	47
1,2-Dichloroethane	28 U	60	5.8 U	5 U	8.2 U	6.0 U
1,1,1-Trichloroethane	37 U	9.3 U	8.3 B	6.7 B	11 U	8.1 U
Benzene	650	5.4 U	72	81	240	400
Carbon Tetrachloride	43 U	910	9.0 U	7.2 U	13 U	9.3 U
1,2-Dichloropropane	31 U	7.9 U	6.6 U	5.3 U	9.4 U	6.9 U
Trichloroethylene	37 U	9.1 U	83	69	39 B	29 B
cis-1,3-Dichloropropene	31 U	7.7 U	6.5 U	5.2 U	9.2 U	6.7 U
trans-1,3-Dichloropropene	31 U	7.7 U	6.5 U	5.2 U	9.2 U	6.7 U
1,1,2-Trichloroethane	37 U	9.3 U	7.8 U	6.2 U	11 U	8.1 U
Toluene	570	6.4 U	81	76	160	270
1,2-Dibromoethane	52 U	1600	11 U	9 U	16 U	11 U
Tetrachloroethylene	46 U	12 U	40 B	35 B	28 B	21 B
Chlorobenzene	31 U	15 B	7.7 B	7.4 B	11 B	12 B
Ethylbenzene	110 B	300	22 B	19 B	32 B	55
m,p-Xylene	120 B	250	35	32	49	82
Styrene	95 B	690	8.6 B	9.2 B	24 B	62
1,1,2,2-Tetrachloroethane	47 U	12 U	10 U	8 U	14 U	10 U
o-Xylene	48 B	84	14 B	14 B	24 B	36
1,3,5-Trimethylbenzene	33 U	25 B	22 B	20 B	28 B	33 B
1,2,4-Trimethylbenzene	60 B	70	73	65	100	110
1,3-Dichlorobenzene	41 U	10 U	9 U	7 U	12 U	9 U
1,4-Dichlorobenzene	130 B	100 B	120	110	170	170
1,2-Dichlorobenzene	41 U	10 U	9 U	7 U	12 U	9 U
1,2,4-Trichlorobenzene	51 U	13 U	11 U	8 U	15 U	11 U
Hexachlorobutadiene	73 U	18 U	15 U	12 U	22 U	16 U

U = Not detected at specified reporting limits.
B = Less than 5 times the detection limit.
μg/m^3= micrograms of analyte collected per dry standard cubic meter of gas sampled.

Table B-11: Summary of Results - Method 16A/6C, Am Test - Air Quality, LLC

File Name: JAA\98-018WD\TRS\SUM
Client: King County Environmental Lab
Location: Renton, Washington

	CENTRIDRY[R] SCRUBBER EXHAUST									
	RUN #1A	RUN #1B	RUN #2	RUN #3	RUN #1	RUN #2	RUN #3	RUN #4	RUN #5	RUN #6
Date:	10/21/97	10/21/97	10/29/97	10/29/97	2/4/98	2/4/98	2/4/98	2/5/98	2/5/98	2/5/98
Start Time:	1000	1035	0950	1100	0955	1147	1420	0850	1100	1330
Stop Time:	1030	1105	1020	1130	1025	1217	1450	0920	1130	1400
Sample Length (minutes):	30	30	30	30	30	30	30	30	30	30
Solids Flow (gpm):	20	20	20	20	20	20	20	20	35	45
Polymer Flow (gpm):	4	4	4	4	2.5	2.5	2.5	2.5	4.3	5.6
Burner Setpoint (^{o}C):	210	210	200	200	160	170	180	160	185	205
Stack Gas Gas Airflow (dscf/min):	494.8	496.6	484.6	484.3	660.2	616.6	640.7	621.7	625.1	658.0
Total Reduced Sulfur Compounds										
Concentration of TRS as SO_2 (ppm):	1.0	0.4 *	0.4 *	1.0	< 0.5 *	< 0.5 *	< 0.5 *	< 0.5 *	< 0.5 *	< 0.5 *
Concentration of TRS as H_2S (ppm):	1.0	0.4	0.4	1.0	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Concentration of TRS as H_2S (mg/dscm):	1.42	0.567	0.567	1.42	< 0.708	< 0.708	< 0.708	< 0.708	< 0.708	< 0.708
Emission Rate of TRS as H_2S (lb/hr):	0.003	0.001	0.001	0.003	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Post-Test System Performance Check										
Calibration Gas Value (ppm):	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1
Dilution Factor:	0.507	0.507	0.507	0.507	0.507	0.507	0.507	0.507	0.507	0.507
Known Concentration of H_2S Gas (ppm):	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1	38.1
System Performance Check Result (ppm H_2S):	37.5	37.5	37.6	37.6	38.2	38.2	38.2	38.0	38.0	38.0
Recovery Efficiency (%):	98.5	98.5	98.8	98.8	100.3	100.3	100.3	99.8	99.8	99.8

* The SO_2 (for TRS) analyzer sensitivity and accuracy is + 0.5 ppm SO_2, which for this test program is 0.5% of a 0-100 ppm scale. The SO_2 analyzer actually has a readability of 0.01 ppm, therefore, some of the readings may be less than the sensitivity and accuracy of the instrument.

Table B-12: Undigested Solids Processing, Process Data and Gas Log, Am Test - Air Quality, LLC

File Name: JAA\98-018WD\KCENV\1MIN
Client: King County Environmental Lab
Location: Renton, Washington
Site Location: Centridry Scrubber Exhaust
Date: March 24, 1998

TIME	BURNER EXIT TEMP °C	POLY FLOW gpm	SLUDGE FLOW gpm	OXYGEN (%)	CARBON DIOXIDE (%)	CARBON MONOXIDE (ppm)	SULFUR DIOXIDE (ppm)	NITROGEN OXIDES (ppm)	TOTAL HYDRO-CARBONS (ppm)
Run 1 - 1154-1245									
1154	217	6	18	14.4	4.2	167.4	1.7	12.3	28.0
1155	217	8	20	13.3	1.8	165.7	1.1	12.6	24.7
1156	217	8	20	14.1	4.3	137.0	0.8	12.1	21.1
1157	217	7	19	14.9	3.8	110.2	0.7	11.3	19.6
1158	217	7	21	14.1	4.4	106.7	0.7	12.2	19.7
1159	217	7	18	13.1	5.0	105.8	0.6	11.4	19.7
1200	217	7	20	12.8	5.2	105.7	0.6	10.9	20.6
1201	217	7	19	12.9	5.1	113.9	0.8	12.1	23.5
1202	217	8	19	13.6	4.6	138.2	0.9	12.6	29.0
1203	217	8	15	14.0	4.4	183.0	1.0	14.8	35.0
1204	217	8	14	14.0	4.4	247.8	1.2	15.1	47.0
1205	217	8	16	13.1	5.0	314.9	1.4	16.1	51.3
1206	217	8	14	12.7	5.3	333.4	1.3	17.4	44.9
1207	220	8	14	12.9	5.1	328.6	1.3	18.2	40.9
1208	217	8	14	14.0	4.4	342.9	1.1	19.1	43.8
1209	217	7	15	15.1	3.8	379.7	1.3	20.4	48.4
1210	217	8	14	14.7	4.0	412.8	1.4	19.2	50.4
1211	217	8	14	13.2	5.0	382.3	1.4	19.4	43.5
1212	217	7	15	12.7	5.2	316.2	1.2	14.4	38.1
1213	217	7	15	12.7	5.3	270.3	1.2	17.3	36.2
1214	217	9	14	12.6	5.3	249.2	1.2	13.2	35.9
1215	217	8	15	12.6	5.3	227.8	1.2	13.0	34.5
1216	217	8	14	12.6	5.3	222.0	1.2	15.3	35.3
1217	217	9	16	12.6	5.3	226.4	1.2	12.6	34.9
1218	217	8	14	12.5	5.3	231.7	1.1	12.1	35.1
1219	217	7	14	12.5	5.4	238.0	1.1	12.4	33.6
1220	217	9	14	12.5	5.4	232.2	1.1	12.3	33.4
1221	220	9	14	12.2	5.6	221.7	1.1	12.6	32.4
1222	220	7	17	11.9	5.8	205.0	1.1	15.3	29.9
1223	220	9	16	12.1	5.6	194.5	1.1	14.5	28.0
1224	220	9	15	12.2	5.5	183.8	1.1	13.6	26.7
1225	220	9	14	12.2	5.6	153.4	1.0	14.4	23.3
1226	220	7	14	12.2	5.5	120.6	0.9	11.9	21.6
1227	220	8	14	12.2	5.6	107.8	1.0	11.7	21.0
1228	220	10	14	12.1	5.6	104.6	0.9	11.6	20.9
1229	220	8	14	12.1	5.6	104.3	1.0	11.4	20.9
1230	220	9	14	12.1	5.6	104.7	1.0	12.4	20.9
1231	220	10	13	12.0	5.7	101.0	1.0	14.7	20.1
1232	220	11	14	12.0	5.7	100.1	1.1	14.3	19.9
1233	220	7	13	12.0	5.7	111.7	1.0	15.0	19.4
1234	220	8	12	12.0	5.7	85.2	1.0	14.3	19.4
1235	220	9	13	11.8	5.8	101.9	0.9	13.3	19.1
1236	220	9	11	11.7	5.9	101.7	0.9	11.8	19.1
1237	220	10	12	11.8	5.8	100.4	0.9	12.3	19.1
1238	220	12	11	11.8	5.8	106.9	0.9	11.2	20.1
1239	220	13	11	11.8	5.8	118.0	1.1	10.8	21.7
1240	220	13	11	11.9	5.7	133.1	1.1	14.0	23.0
1241	220	13	11	12.0	5.7	152.8	1.1	14.1	23.4
1242	220	13	14	12.1	5.6	169.9	1.2	14.4	23.8
1243	220	13	9	12.2	5.5	183.6	1.2	13.9	23.0
1244	220	13	15	12.2	5.5	191.3	1.2	13.5	23.0
1245	220	12	14	12.1	5.6	190.5	1.3	14.5	22.3
Average	**219**	**9**	**15**	**12.7**	**5.2**	**187.3**	**1.1**	**13.9**	**28.7**

C

TAB

APPENDIX C

PRODUCT COMPOSTING AND PRODUCT QUALITY EVALUATION

APPENDIX C-1

EVALUATION OF CLASS A COMPLIANCE ALTERNATIVE FOR CENTRIDRY™ PRODUCT

APPENDIX _C-1

EVALUATION OF CLASS A COMPLIANCE ALTERNATIVES
FOR
CENTRIDRY™ PRODUCT

By

Tetra Tech, Inc.
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Seattle, WA 98101

APPENDIX _C-1

EVALUATION OF CLASS A COMPLIANCE ALTERNATIVES FOR CENTRIDRY™ PRODUCT

1 Introduction

The Centridry™ process combines conventional centrifuge dewatering with direct hot air contact drying in a combined unit. The process yields a product that is dried to a solids content of 50 to 90 percent. The purpose of this evaluation is to identify and assess alternative methods of converting the Centridry™ product into a Class A material as defined in 40 CFR 503.

To evaluate the technology, King County operated a 25-gallons-per-minute Centridry™ facility for a five-month period in late 1997 and early 1998. The facility was located at the South Treatment Plant (STP) in Renton, Washington. The unit processed 4.5 dry tons per day of digested wastewater solids. Some of the dried product from this test period was analyzed for compliance with Class A requirements. Some of the product was composted in test bins and at full-scale composting facilities.

Based on the results of the assessment, conceptual facility designs and cost estimates were developed for two methods of composting the Centridry™ product. Alternatives other than composting were not developed to the same extent because of unresolved issues concerning regulatory compliance.

2 Class A and Vector Attraction Compliance Alternatives

The purpose of this evaluation was to examine and test several options for achieving Class A compliance with the Centridry™ product that are identified in 40 CFR 503 and WAC 173-308. The alternatives identified for initial consideration include:

1 Time and temperature, as defined in 40 CFR 503.32(a)(1) {WAC 173-308-170(2)(a)} Alternative 1.. Acceptable temperatures for dewatered solids range from 15 seconds at 85°C to 14 days at 50°C.
   a) Within unaerated product stockpile at temperatures of >50°C for 14 days (a common European approach to composting Centridry™ product).
   b) Short-duration heat addition to achieve time and temperatures in the range from 5 minutes at 76°C to 1 hour at 68°C. The additional heat could be provided by hot air or steam.

2 Intensive analysis for virus and Helminth organism, as defined in 40 CFR 503.32(a)(5) {WAC 173-308-170(2)(c)} Alternative 3. Based on intensive testing and documentation, the product from a specifically defined and documented process would have Class A status.

3 Periodic analysis for virus and Helminth organism, as defined in 40 CFR 503.32(a)(6) {WAC 173-308-170(2)(d)} Alternative 4. Each batch of product would have Class A status if it passes the required microbiological tests.

4 Heat drying to 90% solids with heating to 80°C (a Process to Further Reduce Pathogens (PFRP), as defined in 40 CFR 503.32(a)(6) {WAC 173-308-170(2)(e)(ii)(B)} Alternative 5 and Appendix B).

5 Composting in-vessel or using the aerated static pile or windrow composting methods (a Process to Further Reduce Pathogens (PFRP), as defined in 40 CFR 503.32(a)(7) {WAC 173-308-170(2)(e)(ii)(A)} Alternative 5 and Appendix B).

Each of these alternatives must also comply with additional testing for Salmonella or Fecal Coliform. Each must also be associated with a process that provides Vector Attraction Reduction (VAR). These VAR methods are designed to reduce the organic content of the material or otherwise change the characteristics to make it less appealing for vectors, such as rodents and insects. The regulation requires that the Class A processing occur before or at the same time as the VAR process if satisfied by biological stabilization.

These regulatory alternatives provide several opportunities for the Centridry™ product to comply with the pathogen requirement. From a processing standpoint, three practical alternatives are available for Class A compliance:

1 Composting of the Centridry™ product using time and temperature or PFRP alternatives
2 Short-duration supplemental heating of the Centridry™ product using time and temperature
3 Centridry™ product without further processing using Helminth and virus monitoring

Vector Attraction Reduction (VAR) is required in addition to pathogen control measures. If biological stabilization is the chosen method of VAR compliance, then (VAR) requirements must be met at the same time or after the Class A Pathogen requirements . Composting is the only Class A stabilization process that is compatible with the Centridry™ process. The VAR requirement for composting is:

1. Aerobic treatment of biosolids for at least 14 days at over 40oC with an average temperature of 45oC per 40 CFR 503.33(b)(5) {WAC 173-308-180(4)} .

Drying and alkaline addition are other VAR processes that could be compatible with the Centridry process. The VAR requirements for these options are:

2. Biosolids that does not contain unstabilized solids, drying to 75% solids content per 40 CFR 503.33(b)(7) {WAC 173-308-180(6)}.
3. Addition of sufficient alkali to raise the pH to at least 12 at 25°C and maintain a pH 12 for 2 hours and a pH 11.5 for 22 more hours per 40 CFR 503.33(b)(6) {WAC 173-308-180(5)}.

Composting was the only VAR process selected for demonstration.

3 Demonstration Program

A demonstration program was completed to test the identified methods of achieving Class A and VAR compliance for the Centridry™ product.

3.1 Short-Duration Heating

To evaluate short-duration heating, steam or hot air could be applied to the dried product to develop a temperature of 70°C for 30 minutes. A test of this approach was not completed because the requirement that VAR be accomplished after or at the same time as the Class A process could not be easily achieved without using another alternative such as composting, drying to 75% solids or lime stabilization. This method may have future potential based on additional technical evaluation and review with regulatory agencies.

3.2 Analysis of Centridry™ Product Without Further Processing

The heating phase of the Centridry™ process exposes pathogenic organisms to heat and drying, which are known to inactivate these organisms. However, sufficient performance information has not been developed to document that the product complies with the Class A requirement using Class A Alternative 3 or 4. During the testing program, some product taken directly from the Centridry™ unit was analyzed using EPA-approved procedures for fecal coliform, *Salmonella* sp., virus, and viable helminth ova to determine compliance with 40 CFR 503 Class A Pathogen Control Alternative 4.

Two samples of Centridry™ product were analyzed for all 40 CFR 503-identified pathogens. Five additional tests were analyzed only for fecal coliform and *Salmonella* sp. The results are shown in Table 1.

Testing of the Centridry™ product for pathogens indicates compliance with the virus and helminth requirements of Class A Alternative 4 at the time of testing. The data indicates that it may be desirable to seek compliance using Class A Alternative 3, which documents that the process consistently complies with the virus and helminth requirement. The option is also available to annually test a product for compliance. However, the annual testing approach leaves significant question about how to operate the program if a sample does not meet the Class A standard. A contingency plan would be essential for using this approach. Re-sampling and process review would be desirable. Reprocessing the material or diversion to Class B usage are available alternatives.

Table 1 – Pathogens in Centridry™ Product

Sample Date	*Fecal coliform*[1] *(MPN/g dry wt.)*	*Salmonella sp.*[2] *(MPN/4 g dry wt.)*	*Virus*[3] *(PFU/4 g dry wt.)*	*Helminth Ova*[4] *(#/4 g dry wt.)*
7/1/97 (#1)	(<MDL)	(<MDL)	(<MDL)	NF
7/1/97 (#2)	(<MDL)	(<MDL)	(<MDL)	NF
9/15/97	150	(<MDL)		
1/12/98	2.1	(<MDL)		
1/19/98	0.3	(<MDL)		
1/26/98	1.2	(<MDL)		
2/2/98	47	(<MDL)		

[1]Fecal coliform wet MDL = 20 MPN/100 g; 503 limit 1,000 MPN/g total solids (dry weight basis)
[2]*Salmonella* sp. wet MDL = 2 MPN/100 g; 503 limit organisms 3 MPN/4 g total solids (dry weight basis)
[3]Virus wet MDL = 2 PFU/100 g; 503 limit organisms 1PFU/4 g total solids (dry weight basis)
[4]NF = None Found; 503 limit organisms 1 viable helminth ova/4 g total solids (dry weight basis)
MDL = Method Detection Limit
g = gram
PFU = plate forming unit
wt. = weight
MPN = most probable number

Another source of information about the pathogen content of the Centridry™ product is provided by the initial samples of the bin test mixes. All samples containing only Centridry™ product or in combination with sawdust were well below the limits for fecal coliform and *Salmonella* sp. before composting was initiated.

If the product does not comply also with one of the VAR options, it will not be a Class A product.

3.3 Composting Bin Tests

A bin testing program was used to improve knowledge about a large number of alternative composting options while using limited space and support resources. The following issues were evaluated during bin testing:

1. Adequacy of moisture available in the Centridry™ product to provide PFRP and produce a stable compost product
2. Availability of sufficient energy (degradable organics) to achieve PFRP and VAR
3. Extent of nitrogen loss when composting dried solids without a bulking material
4. Suitability of the Centridry™ product texture for aeration without bulking material addition
5. Extent of active composting (biological degradation) versus heat retention through product insulative properties
6. Bulking material usage for moisture, energy, or texture enhancement of the dried product
7. Odor associated with the final product in a dried and rewetted state
8. Odor associated with composting
9. Density characteristics of the Class A products and transportation cost implications
10. Potential for compliance with Class A pathogen requirements for fecal coliform or Salmonella.

Eight different mixes using Centridry™ wastewater solids alone or with selected bulking materials were composted in four 20-cubic-foot-capacity composting bins. A cement mixer was used to mix the bulking materials and wastewater solids. The mixes were then manually loaded into the bin composters. The mixes were composted for at least 21 days, during which temperature was maintained within optimum levels using a temperature feedback controller. The system was operated to achieve temperatures in excess of 55°C for three days for compliance with PFRP. The bins were controlled to provide compliance with VAR per 40 CFR 503.33(b)(5), which requires temperatures greater than 40°C for 14 days with an average greater than 45°C.

Experience in Europe with static pile composting of the dried product indicates the possibility that sufficient heat is released by the newly dried product to maintain composting temperatures in static, unaerated piles (Schilp & Epper). Also in Europe, aeration was found to cool the piles below required temperatures (Newman, G., Wolstenholme, P.) but was successfully used at Gruneck (Schilp). The rate of aeration at which over-cooling occured was not indicated. The energy released to heat the unaerated composting piles appeared to be provided by a Volatile Solid (VS) reduction of 12 percent. The solids content of the material tested in this manner was 60 percent. During three months of storage, the solids had sufficient energy to further dry the product to 75 percent solids (Schilp & Epper). Based on this experience, it was desirable to use the bins to better define the conditions under which this approach could be used.

A variation of the European approach that might provide compliance with the Class A requirement uses an insulating blanket of Class A product to assure development of required temperatures throughout the static pile.

The test mixes were selected based on experience with the product in Europe and traditional approaches to composting.

Traditional composting of dewatered biosolids typically involves the addition of a bulking material to condition the mix for effective biological activity and the provision of a moist, aerobic environment. Drying the solids to the levels achieved by Centridry™ significantly changes the physical characteristics of the solids and the need for a bulking material to increase the solids content of the mix into the ideal range for composting. In fact, Centridry™ product is drier than normally desirable for composting. In this case, a bulking material may be desirable to add moisture and to provide porosity to improve the movement of air through the material. A goal in developing the recommended initial mixes was to test different bulking material ratios in order to evaluate whether the bulking material mixes outperform the dried product by itself.

Prior to the compost bin testing, a trial run was conducted to demonstrate the perfomance of the bins and train the operation and monitoring personnel. During this preliminary test some unusual odors were observed. The first series of tests were designed to demonstrate the unaerated method used in Europe, an aerated version of teis method, a typical aerated static pile mix with bulking material and aeration and a mix seeded with active aerobic bacteria to replenish bacteria on the surface of the Centridry particles. The following mixes were used to address these issues during bin testing:

Series 1, Digested Solids Feed

Bin 1, 100 percent Centridry™ product without aeration – This models the European experience as closely as possible using STP biosolids.
Bin 2, 100 percent Centridry™ product with aeration – This models the aeration experiment conducted in Europe, but with controlled aeration rates.
Bin 3, 33 percent Centridry™ product and 67 percent coarse, moist sawdust bulking material (2 to 1 mix by volume bulking material:centridry) with aeration – This mix models the aerated static pile process using sawdust as the bulking (and moistening) material. The mix ratio includes less sawdust than used in traditional composting but provides enough to identify any positive benefit of adding sawdust.
Bin 4, 43 percent Centridry™ product; 43 percent coarse, moist sawdust bulking material; and 14 percent thickened undigested wastewater solids (THS) (1:1:1/3 mix) with aeration – This mix models the aerated static pile process using sawdust as the bulking material and thickened solids for moisture addition and microorganism seeding. The seeding was felt to be potentially beneficial for odor control by replacing desired microorganisms lost in the drying process.

The operation of the Centridry equipment was being tested concurrently with the composting tests. As a result, the character of the dried product was changing through the operating period. Following completion of the first composting test series the results were considered along with the performance of the drying system in selecting the mixes and operating conditions to be used in the secong series. The objectives of the second test series were:

- Replicate the initial tests with 100 percent Centridry product and traditional bulking mateial mix using a Centridry product with greater moisture content to determine if composting is improved with more water.
- Evaluate unaerated composting of Centridry product that has been held in storage prior to composting. This test was designed to replicate potential operating conditions and the preliminary test that resulted in unusual odors.

Series 2, Digested Solids Feed

Bin 1, 100 percent Centridry™ product without aeration – Replicate of Bin 1 – Series 1.
Bin 2, 100 percent Centridry™ product with aeration – Replicate of Bin 2 – Series 1.

Bin 3, 33 percent Centridry™ product and 67 percent coarse, moist sawdust bulking material (2:1 mix) with aeration – Replicate of Bin 3 – Series 1.
Bin 4, 100 percent Centridry™ product that was pre-aged in unaerated storage for three weeks, with aeration – Replicate of Bin 2 – Series 1 using aged material to evaluate the effects of storage prior to composting.

During the four-week composting period, composting material samples were collected and analyzed for process status parameters. Odor emissions were monitored during composting using colorimetric tube and odor panel analyses. The odor panel analysis was completed by a seven-person panel using ASTM-consistent equipment, sampling procedures, and measurement procedures. At the end of the composting process, the volume and weight of product was determined.

3.3.1 Compost Bin Testing Results

The bin tests were completed September of 1997 and January of 1998. Although the bins are insulated the air being fed to the aerated units, solar radiation on the bins and wind cooling will have some impact on the performance of the tests. The bins were located on the south side of a building exposed to solar radiation and soutnerly winds. The first three weeks of testing when PFRP and VAR compliance is achieved would be the most sensitive to weather conditions. The first week of the first test series was fairly warm with high temperatures in the 70's to low 80's and calm to light northerly winds. The remainder of the period was cooler with highs in the 50's to low 60's with winds generally from the south. The first three weeks of the second test series was quite variable with highs ranging from the mid 30's to the low 60's. Winds were generally moderate and from the south.

3.3.1.1 Sufficient energy to achieve PFRP and VAR

The temperatures observed during the two series of bin tests are presented in Figures 1 and 2. The performance of the bin composting tests indicate that the Centridry™ product generates temperatures that are required for 40 CFR 503 Class A and VAR compliance. Energy release seems to be suitable for full-scale composting situations despite some problems maintaining temperatures in the bins. Larger piles will provide more insulation and retain the released heat. The bin aeration rates were controlled manually which likely resulted in much of the variabilty. Some of the temperature differences between the two test series may be due to manual aeration control or external temperatures and wind. Although the bins were insulated, some effects from the differing conditions in September/October versus January/February would be expected.

Figure 1: Centridry Bin Temperatures - Test Series 1 beginning September 16, 1997

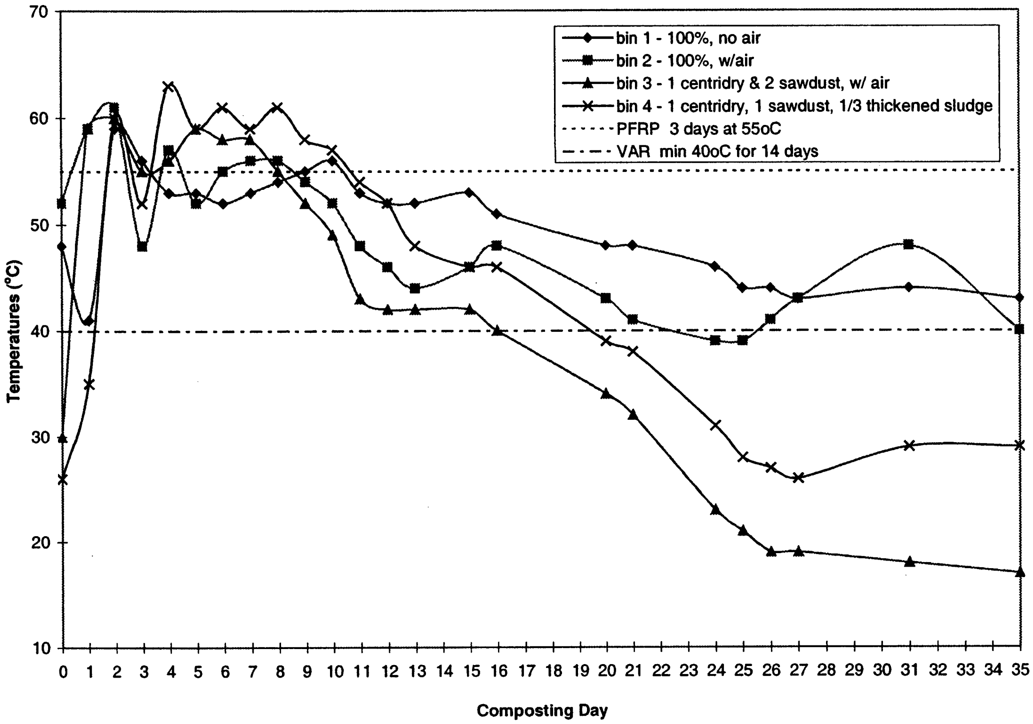
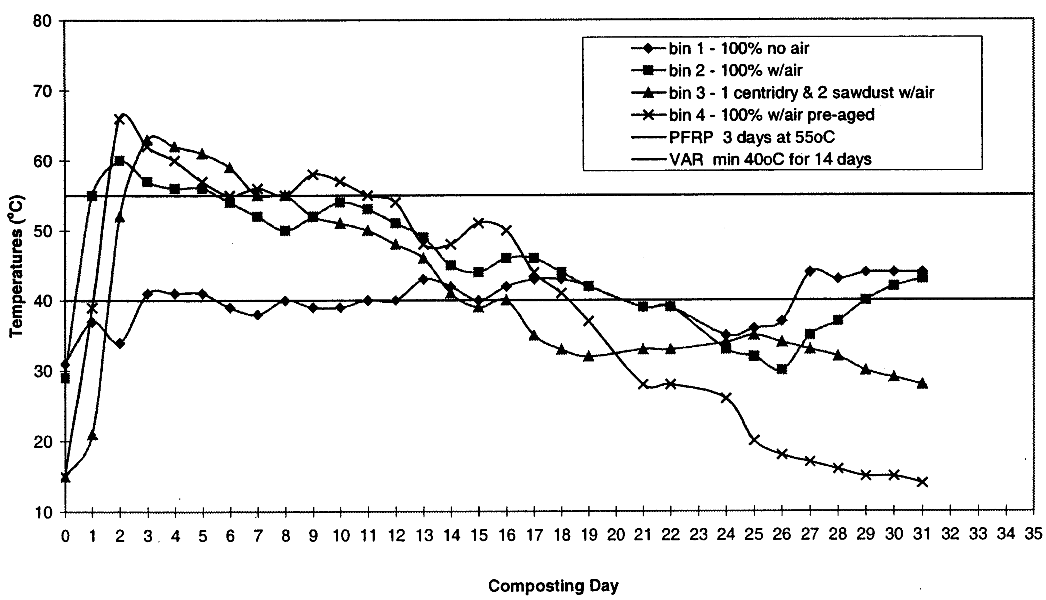


Figure 2: Centridry Bin Temperatures - Test Series 2 beginning January 27, 1998



The failure of the unaerated bin containing only Centridry product to achieve PFRP temperatures may be a result of inadequate insulation. A larger pile would likely provide better insulation and result in PFRP temperatures.

3.3.1.2 Biological Degradation And Heat Retention Properties

The degradation of organic matter remaining in the Centridry product was measured by observing changes in the volatile solids content. This data provided an unclear picture. The first bin test series results indicated a volatile solids reduction variation from 40 to 56 percent on a weight basis. This agreed with the generated temperatures and water removal that was observed. The second bin test data indicated that organic energy was converted to heat but the volatile solids data showed minimal reduction in any of the bins. Water removal was also generally less and more variable than in the first bin series. Regardless of this inconclusive information, the temperature data clearly shows that the material is generating and retaining suficient heat to comply with PFRP requirements.

3.3.1.3 Moisture available to produce a stable compost product

The changes in moisture content during the bin testing is shown in Table 2. Normally, the initial moisture content of a composting mixture would be adjusted to 60 percent water content. Only one of the mixes in each test series was near this condition. The other mixtures were relatively dry for composting. Moisture content data indicates significantly further drying of the Centridry™ product during composting. In all cases, the compost product was dry, although the mixes with sawdust and THS seemed to retain more moisture. It is likely that the biological process is being impacted by the lack of moisture. Moisture and dust control should be considered as part of compost facility design because of the potentially dusty nature of the product observed throughout the composting process.

Table 2 – Moisture Contents during Bin Composting (% moisture)

Test Series 1	*Test Day 0*	*Test Day 8*	*Test Day 35*
Bin 1: 100 percent, no air	46	42	33
Bin 2: 100 percent, w/air	46	37	32
Bin 3: 1:2 mix	48	42	39
Bin 4: 1:1:1/3 THS, w/air	62	60	54
Test Series 2	*Test Day 0*	*Test Day 8*	*Test Day 14*
Bin 1: 100 percent, no air	42	35	27
Bin 2: 100 percent, w/air	40	34	27
Bin 3: 1:2 mix	58	52	52
Bin 4: 100 percent aged, w/air	45	36	27

The second series of bin tests used Centridry™ product that had a 5 percent lower moisture content than the first series. There is some indication that the reduced moisture content may have slowed the composting process and reduced operating temperature in the 100 percent Centridry™ product tests.

3.3.1.4 Nitrogen Loss When Composting Without A Bulking Material

Table 3 shows ammonia levels measured by colorimetric tubes in the bin offgas or headspace early in the composting period. The ammonia concentrations appear to be very different for the two test series. In the second series, a direct comparison between the fresh and the aged products with aeration seems to indicate greater ammonia release after aging. However, the failure of series 2, bin 1 to reach composting temperatures may have reduced ammonia release. In general the data indicates that high concentrations of ammonia are released regardless of the test mix. This requires consideration during planning and design of a full scale composting facility.

Table 3 – Offgas Ammonia Concentrations (ppm)

	Test Series 1			
	Test Day 2	*Test Day 3*	*Test Day 8*	*Test Day 15*
Bin 1: 100 percent, no air	1,000	400	30	No data
Bin 2: 100 percent, w/air	900	475	40	No data
Bin 3: 1:2 mix	650	225	60	No data
Bin 4: 1:1:1/3 THS, w/air	520	300	30	No data
	Test Series 2			
Bin 1: 100 percent, no air	No data	200	135	120
Bin 2: 100 percent, w/air	No data	120	65	80
Bin 3: 1:2 mix	No data	80	150	90
Bin 4: 100 percent aged, w/air	No data	480	120	160

In all mixes, organic nitrogen is being converted to ammonia. Ammonia comprises 33 to 48 percent of the Total Kjeldahl Nitrogen (TKN) of the mixes after 35 days. Most of the ammonia is held in the mix despite the low carbon-to-nitrogen (C:N) ratio, high pH of 8.0 to 8.7, low moisture content, and increased ammonia concentration. The straight Centridry™ product bins experienced significantly less nitrogen loss than the mixes with bulking agent. These findings are contrary to the normally accepted relationship between C:N ratio, pH, moisture content, and nitrogen loss. Normally, much greater loss of ammonia would be expected for the observed conditions in the bins. The character of the particles produced by the Centridry™ process may impede the movement and release of ammonia generated within the particles.

3.3.1.5 Aeration Without Bulking Material Addition

Aeration of the Centridry product with no added bulking materials worked well at the shallow depths used in the bins. Demonstration of composting at full scale operating depths is recommended prior to implementation of composting without bulking material.

3.3.1.6 Bulking Material Effects

The bin test data does not indicate any primary benefits associated with using a bulking material when composting the Centridry product in this small scale test procedure. The potential for composting without bulking material provides the opportunity to simplify the composting process and reduce capital and operating costs.

3.3.1.7 Composting Odor

Odor analyses results from the second bin testing series are shown in Table 4. Air samples were collected in Tedlar bags from the headspace above each of the bins. The samples were analyzed using as estabished odor panel procedure (ASTM 1991). Odor detection determines the threshold at which odor can be detected in a given air sample. The resulting measure (dilutions to threshold or D/T) is the number of volumes of odor free air required to reduce one volume of odorous air to the median human detection threshold. The sample analysis entail presenting the air sample at increasingly higher concentrations to each member of an 8 to 10 person panel using an olfactometer.

The test results shaow that odor levels appear to be lowest in the unaerated bins. The highest initial odors were in the sawdust mix and aged Centridry™ product with aeration. In both of these cases, the odor levels were reduced by half or more after 15 days. Odors were observed to be generated during initial mixing and placement of the material and during composting.

Table 4 – Odor during Series 2 Bin Testing (dilutions to threshold)

Bin	*Day 3*	*Day 8*	*Day 15*
Bin 1: 100 percent, no air	1,121	1,222	1,096
Bin 2: 100 percent, w/air	1,990	1,358	1,079
Bin 3: 1:2 mix	3,517	1,797	1,410
Bin 4: 100 percent aged, w/air	3,450	1,915	1,746

3.3.1.8 Final Product Odor

Although no measurements were made of odor from the composted product, anecdotal concensus was that the product had a recalcitrant characteristic and not entirely desirable odor.

3.3.1.9 Density Characteristics And Transportation Cost Implications

The composted product density appears to vary from 30 to 35 pounds per cubic foot or 48 to 56 percent of the density of water. The current County long haul trucks are capable of transporting loads of 33 tons or 58 cubic yards. At those densities the trucks at maximum volume capacity would carry 23 to 28 tons of composted Centridry product. However, the composting process reduced the product volume by 20 to 25 percent and the product weight by 10 to 50% depending on water removal. A wet ton of solids fed to the Centridry process would be converted to roughly 0.3 wet tons of Centridry compost. Hauling the Centridry compost would required 35 percent as many truck trips as hauling dewatered solids.

3.3.1.10 Potential For Compliance With Class A Fecal Coliform or Salmonella Requirements

The results of the microbiology analyses for both test series are provided in Table 5. None of the initial mixes contained detectable levels of *Salmonella* sp. With the exception of the single mix containing raw solids, the initial mixes and all product mixes were below the Class A requirement for fecal coliform.

Table 5 – Microbiological Evaluation Results for Bin Tests

Parameter	*Bin 1 Mix*	*Bin 2 Mix*	*Bin 3 Mix*	*Bin 4 Mix*	*Sawdust*
		***Salmonella* sp. (MPN/4 g dry wt.)**			
Series 1					
Day 0	<0.16	<0.16	<0.16	<0.2	<0.16
Day 35	<0.12	<0.16	<0.12	<0.12	
Series 2					
Day 0	<0.12	<0.12	<0.2	<0.2	<0.24
Day 28	<0.12	<0.12	<0.12	<0.16	
		Fecal coliform (MPN/g dry wt.)			
Series 1					
Day 0	4	34	97	1,300,000	2.6
Day 35	0.89	2.2	2.8	450	
Series 2					
Day 0	0.34	<0.3	0.47	48	0.63
Day 28	<0.3	<0.3	120	<0.4	

3.4 Full-Scale Composting

Following the bin testing, a full-scale composting test was initiated based on the bin test results. The testing was conducted at two commercial composting facilities in the Seattle region. The material was composted to determine the suitability of the material for commercial production, considering odor potential, bulking material requirements, and product market value.

Full-scale composting tests were conducted by GroCo, Inc. and Land Recovery, Inc. (LRI). GroCo has been composting dewatered biosolids from generators in the Seattle region for over 25 years. GroCo, located in Kent, Washington, uses the large static pile method of composting a mix of one part by volume dewatered biosolids with three parts sawdust. LRI currently operates the Pierce County Yard Debris Composting Facility at Purdy, Washington and a NatureTech Bin System at the Hidden Valley Transfer facility located near Puyallup, Washington. The NatureTech system uses modified drop boxes and an automated aeration system to provide a temperature-controlled composting environment. LRI tested the Centridry™ product in the bin system. Figure 3 shows data from LRI to-date.

GroCo tested three mixes:

1 4:2:2 mix by volume of sawdust, dewatered biosolids, and Centridry™ product
2 3:1 mix by volume of sawdust and Centridry™ product
3 2:1 mix by volume of sawdust and Centridry™ product

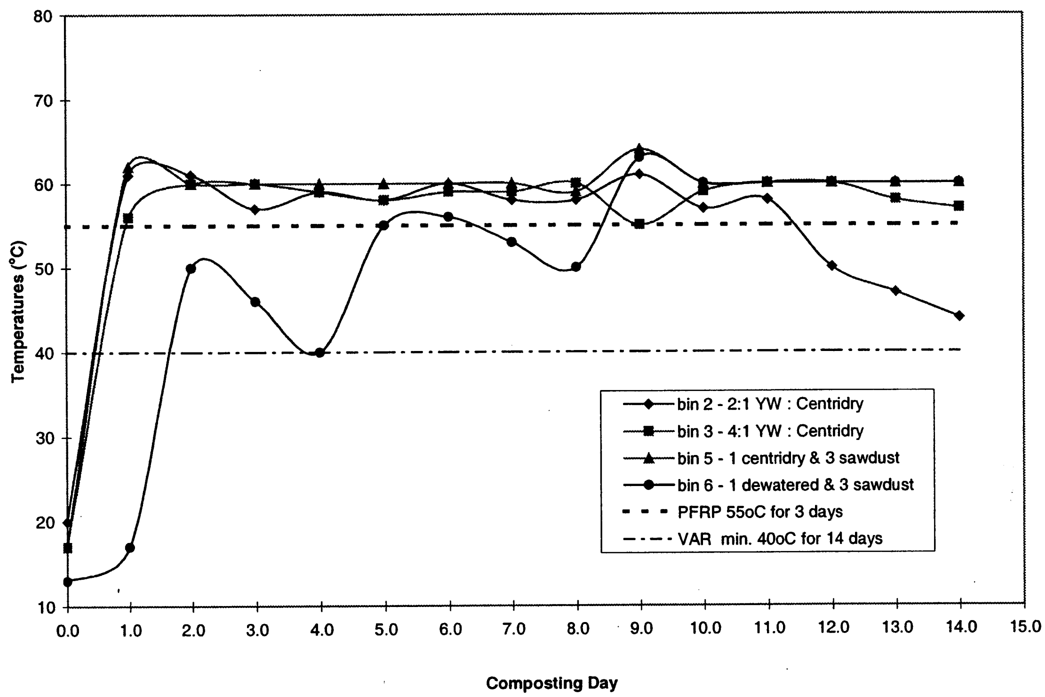
LRI tested four mixes:

1 2:1 by volume of yard debris and Centridry™ product
2 4:1 by volume of yard debris and Centridry™ product
3 3:1 by volume of sawdust and Centridry™ product
4 3:1 by volume of sawdust and dewatered biosolids

All three mixes at GroCo appeared to be composting well during a site visit. Temperatures were measured in a range between 40°C and 50°C. Oxygen levels were measured at 7 to 12 percent at a one-foot depth and decreased to 1.5 to 3 percent at a three-foot depth. Odor from all three piles was observed to be minimal. The surface layer of material had an earthy smell, indicating aerobic conditions. The only concern expressed by the processor was odor during the delivery, initial mixing, and placement steps. Facility personnel reported odor and dust associated with the product and initial mixing activity.

All four mixes composted well at the LRI facility. The temperature record for the initial composting period is provided in Figure 3. The dewatered biosolids mix was initially too wet but still reached composting temperatures after an initial lag period. Facility personnel reported odor and dust associated with the product and initial mixing activity.

Figure 3 - LRI Test Temperatures



3.5 Compost Testing Conclusions

The performance of the bin and full-scale composting tests indicate that the Centridry™ product generates temperatures that are required for 40 CFR 503 Class A and VAR compliance. Odors were found to be generated during initial mixing and placement of the material and during composting. The full-scale tests indicate that these odors may be adequately controlled once composting is initiated. Additional evaluation of the effectiveness of biofiltration and other odor control measures is warranted based on concerns expressed by LRI.

In all bin tests and mixes, organic nitrogen is being converted to ammonia. Ammonia comprises 33 to 48 percent of the TKN of the mixes after 35 days. Most of the ammonia is held in the mix despite the low C:N ratio, high pH of 8.0 to 8.7, and increased ammonia concentration. The straight Centridry™ product bins experienced significantly less nitrogen loss than the mixes with bulking agent. This finding is contrary to the normally accepted relationship between C:N ratio and nitrogen loss.

The product from the LRI tests was analyzed for stability, maturity and other parameters of importance for use as a soil amendment. The results indicate that all of the mixes were stable and mature except for the mix of Centridry™ product and sawdust. This mix was mature but moderately un-stable. The analytical results do not indicate why this mix was more biologically active after the completion of composting.

Additional analysis and evaluation of product quality is desirable to better determine the potential market value of the composted product. Topsoil and other soil amendment blends or compost from co-composting of Centridry™ product and yard waste are the most likely uses for this product.

4 Composting Alternative Analysis

The broad objective of this analysis is to identify alternatives for providing a Class A Centridry™ product for beneficial use within the County service area that reasonably reflects costs in comparison to other options for managing a Centridry™ biosolids product. Composting is an available process that provides a relatively high level of confidence that a stable program could be developed for managing a Class A Centridry™ product. The focus market for this product would be as a component of a manufactured topsoil mix. The objective of this portion of the evaluation is to identify a composting strategy that reasonably represents the type of composting process that may be implemented, the intent being to use the chosen composting process as the basis of a cost-effectiveness analyses. If composting is selected as a part of the biosolids management strategy, additional evaluation would be necessary to refine and optimize the composting process prior to implementation.

4.1 Composting Feedstock Mix/Bulking Material Alternatives

The mix design approaches considered for the Centridry™ product include:

1. A product with no additives,
2. A product with an added bulking material that remains a part of the product (e.g., sawdust), and
3. A product that is composted with a bulking material that is mostly screened out of the product and recycled to the composting process.

All three of these approaches were tested during the bin and full-scale testing.

Sawdust appears to be a viable bulking material that remains as part of the product. The product character would be similar to GroCo, which has a long, successful marketing history in the Seattle area. A sawdust-based compost product could be produced by the County or by a contract processor, such as GroCo.

A composted Centridry™ product with no additives would have characteristics very similar to freshly dried material. Composting does not seem to result in a major change in physical appearance. This material would likely be most effectively marketed as a topsoil blend or Tagro-type product. Composting with a bulking material that is screened back out and recycled back to composting (e.g., wood chips) would not seem to be a benefit. The cost of the bulking material, larger facility, and additional material handling would not result in a more marketable or valuable product.

LRI has successfully composted the Centridry™ product with yard debris. Contract processing of the product at a yard debris composting facility would likely result in a high quality compost.

Based on this assessment, the economic evaluation should include alternatives for composting the Centridry™ product with sawdust and without a bulking material.

4.2 Composting Technology Alternatives

A variety of composting technologies have potential application for the Centridry™ product. A summary listing of technologies includes:

1 GroCo large static pile
2 Aerated static pile
3 Windrow
4 Aerated windrow
5 Agitated bed
6 Dutch tunnel
7 Containerized systems

The primary characteristics of the Centridry™ product that would influence the selection of a composting technology include:

1 Odor potential
2 Dust management
3 Moisture control

Considering the need for a simple, proven, controllable process that offers minimal opportunities for odor or dust release, the aerated static pile process is selected as the process to be used for the initial economic feasibility of composting the Centridry™ product.

5 Economic Analysis

An alternative analysis and cost evaluation was developed for composting of the Centridry™ product based on the information developed during the bin and full-scale testing. These cost estimates are for use in comparing composting to other methods of managing the Centridry™ product as part of the County's biosolids management program.

The selected composting process is the extended aerated static pile. This technology was selected on the basis of compatibility with bin and full-scale tests, proven operating experience with biosolids, simplicity, flexibility, odor and dust control capability, and cost effectiveness. The process is designed to provide a Class A biosolid suitable for use as a compost or topsoil product but possibly requiring further processing. Additional processing could include curing of the material or blending with other materials. Listed below are the design criteria assumed for the facility design concept to be used in developing an estimated cost of composting. Again, this composting process is intended to be representative of a reasonable and cost-effective approach and is not intended to represent the selection of a composting method that might ultimately be selected for implementation.

1 Generic compost facility design that could be used at South Treatment Plant or at another appropriate location within King County
2 Centridry Product Capacity of 30,200 wet tons per year at 55 percent solids or 60 dry tons per day on a 7-days-per-week basis as a 21 day peak.
   a)
3 Front-end wheel loader for pile formation and breakdown
4 Cost estimates have been developed for two feedstock mixes:
   a) Straight Centridry™ product at 55 percent solids
   b) A mix of 2 parts by volume sawdust to 1 part by volume Centridry™ product
5 Extended aerated static pile composting with flush aeration floor using negative aeration on a concrete pad; a design detention time of 21 days at peak 21 day loading – During this period, both Class A pathogen and VAR requirements would be satisfied. The static piles are limited to 5 foot depth of Centridry product and a 7 foot depth for the sawdust / Centridry mix. An insulating cover of composted product would be used in either case.
6 No on site curing of the composted product.
7 Fully enclosed composting area.
8 Dust control capability for the operating areas and specific focus areas expected to have significant dust release
9 Covered and aerated storage area with capacity for 7 days of production at peak 21-day loading
10 Biofiltration of all process and building ventilation air
11 All operations by County employees
12 7-days-per-week operation
13 Enclosed portable batch mixer and mixing area for the sawdust blend only
14 Covered bulking material storage area (30 operating days' capacity at peak 21-day loading) for the sawdust blend only

A cost comparison was completed for composting the Centridry™ product using the aerated static pile process. The results of the cost comparison are provided in Table 6. As shown, the cost of composting the Centridry™ product without a bulking material is significantly less than composting with sawdust. The primary cost-reducing factors associated with composting without a bulking material are a smaller enclosure and no cost for purchasing the bulking material. The added volume of material being processed results in a doubling of the size of the enclosed composting building. The cost of the bulking material represents the largest annual cost of operations. The cost of composting the undiluted product is competitive with current land application and composting operations operated by the County.

Table 6 – Cost and Space Requirements Comparison

Requirements		*2 parts sawdust to 1 part Centridry™ product*	*Centridry™ product only*
Site Area	acres	5.4	2.7
Enclosed Building Area	sf	116,000	63,200
Capital Costs	$		
Biofilter and Site Improvements	$	1,860,000	1,040,000
Structures	$	3,750,000	1,890,000
Equipment	$	2,570,000	1,120,000
Electrical and Controls	$	470,000	230,000
Subtotal	$	8,650,000	4,280,000
Contingency	$	2,160,000	1,070,000
Administration and Engineering	$		
Sales Tax	$	930,000	460,000
Total Capital Cost	$	11,740,000	5,810,000
O&M Cost			
Labor	$/yr	465,000	275,000
Materials	$/yr	105,000	45,000
Odor Control	$/yr	120,000	100,000
Energy	$/yr	195,000	75,000
Miscellaneous	$/yr	140,000	100,000
Bulking Material	$/yr	370,000	0
Total	$/yr	1,400,000	595,000
Product volume	yd^3/yr	152,000	50,000
Unit Cost	$/WT	86	39
	$/DT	157	71

6 Conclusions

The evaluations of the Centridry process as a means to developing a family of Class A processes leads to the following primary conclusions:

1. Composting can be used to produce a Class A biosolid product. This is accomplished by complying with the aerated static pile PFRP process and the time and temperature procedure for vector attraction reduction. Based on pilot testing, Class A status can be achieved with 16 to 20 days of composting. The Centridry™ product can be composted in this manner with or without bulking material.
2. Based on full scale testing, composting of Centridry™ product without bulking material may not produce a stable and mature compost product suitable for direct distribution to consumers. In addition, the appearance, odor and texture of this product would likely limit the potential market demand.
3. Composted Class A Centridry™ product, either with or without a bulking material, is likely a valued component for topsoil manufacturing. The potential quantity demand and value of the product is not currently understood. The availability of sufficient quantities of product to allow evaluation by the industry will be required before the potential market scope and value can be defined.

Additional technical conclusions resulting from testing of the Centridry product include:

1. Class A compliance for the Centridry™ product directly after drying may be attainable using 40 CFR 503 Alternative 3 or 4. Class A and VAR requirements of 40 CFR 503 can be met by composting the Centridry™ product. However, energy release was slow for one unaerated test, indicating that adequate insulation would be required to achieve the desired temperatures using the European style of composting this product.
2. Nitrogen loss does not appear to be a major problem during composting of the Centridry™ product.
3. Experience in the Centridry™ demonstration project indicates odor release may be problematic during storage, handling, and composting. Preliminary results indicate that the odors are controllable during composting using the static pile process and by treating in a biofilter.

If implementation results in the consistent availability of a Centridry product, then demonstration and evaluation of the following Class A compliance options is recommended:

1 Comprehensive composting process selection prior to implementation of composting as a biosolids management method including:
 a) Dust control procedures for composting of Centridry™ product
 b) Odor control methods for composting of Centridry™ product
2 Test marketing of Centridry™ product compost for use as a topsoil blend component or as a Tagro-type product
3 Further exploration of complying with the Class A requirements using Alternatives 3 or 4, as identified in 40 CFR 503
4 Providing Class A compliance by maintaining the Centridry™ product at 70°C for 30 minutes – The regulatory viability and economics of this method have not been fully evaluated.

7 References:

American Society of Testing and Materials (ASTM); Standard Practice for Determination of Odor and Taste ThresholdsBy Forced-Choice Ascending Series Method of Limits, 1991.

Schilp, R., Epper, W.; Centridry® - a Process for Combined Dewatering and Drying of Sewage and Industrial Sludges, Undated

Newman, G., Wolstenholme, P; Site Visit to German Installations, 3/7/96

Schilp, R. Presentation to King County Centridry Project Team, 1/14/97

APPENDIX C-2

LRI AND GROCO COMPOSTED CENTRIDRY™ PRODUCT EVALUATION

LRI Composting of Centridry product

2:1 mix yard waste:Cdry Date	pH	Total Solids (%)	Total Volatile Solids (%)	NH_4-N (mg/kg)	TKN (mg/kg)	**Org-N (mg/kg)**	NO_3-N (mg/kg)	TP (mg/kg)	Potassium (mg/kg)	Ave Temp (°C)	Air Flow (cfm)	Lab Bulk Density (g/ml)	Lab Bulk Density (lbs/cy)	Field Bulk Density (lbs/5 gal)	Field Bulk Density (lbs/cy)	Micro Results Salmonellae (MPN/100g)	Fecal Coliform (MPN/100g)
3-Mar	7.69	49.8	30.8	466	20,100	**19,634**		3,350	3,230			0.791				<MDL	4.60E+08
18-Mar	8.50	55.2	30.6									0.757					
1-Apr	7.70	43.9	25.3									1.08					
20-Apr	8.05	54.9	27.9		29,100			2,170	3,700			0.783				<MDL	2.40E+06

4:1 mix yard waste:Cdry Date	pH	Total Solids (mg/L)	Total Volatile Solids (mg/L)	NH_4-N (mg/kg)	TKN (mg/kg)	**Org-N (mg/kg)**	NO_3-N (mg/kg)	TP (mg/kg)	Potassium (mg/kg)	Ave Temp (°C)	Air Flow (cfm)	Lab Bulk Density (g/ml)	Lab Bulk Density (lbs/cy)	Field Bulk Density (lbs/5 gal)	Field Bulk Density (lbs/cy)	Micro Results Salmonellae (MPN/100g)	Fecal Coliform (MPN/100g)
3-Mar	7.50	45.6	27.3	346	21,900	**21,554**		2,960	3,750			0.787				4.4	6.10E+08
18-Mar	8.96	54.5	31.5									0.714					
1-Apr	8.30	42.4	21.2									1.33					
20-Apr	7.94	52.6	26.4		24,700			3,840	4,870			0.985				<MDL	1.50E+07

3:1 mix sawdust:Cdry Date	pH	Total Solids (mg/L)	Total Volatile Solids (mg/L)	NH_4-N (mg/kg)	TKN (mg/kg)	**Org-N (mg/kg)**	NO_3-N (mg/kg)	TP (mg/kg)	Potassium (mg/kg)	Ave Temp (°C)	Air Flow (cfm)	Lab Bulk Density (g/ml)	Lab Bulk Density (lbs/cy)	Field Bulk Density (lbs/5 gal)	Field Bulk Density (lbs/cy)	Micro Results Salmonellae (MPN/100g)	Fecal Coliform (MPN/100g)
3-Mar	8.04	44.5	34.4	461	24,700	**24,239**		4,520	1,400			0.631				<MDL	2.90E+07
20-Mar	8.68	50.6	39.8									0.595					
1-Apr	8.25	35.6	27.8									1.06					
20-Apr	8.14	51.0	40.1		23,500			5,430	1,650			0.557				<MDL	<MDL

3:1 mix sawdust:mech Date	pH	Total Solids (mg/L)	Total Volatile Solids (mg/L)	NH_4-N (mg/kg)	TKN (mg/kg)	**Org-N (mg/kg)**	NO_3-N (mg/kg)	TP (mg/kg)	Potassium (mg/kg)	Ave Temp (°C)	Air Flow (cfm)	Lab Bulk Density (g/ml)	Lab Bulk Density (lbs/cy)	Field Bulk Density (lbs/5 gal)	Field Bulk Density (lbs/cy)	Micro Results Salmonellae (MPN/100g)	Fecal Coliform (MPN/100g)
3-Mar	7.79	30.5	25.7	390	20,300	**19,910**		2,040	1,300			1.37				<MDL	9.80E+06
20-Mar	8.57	32.8	28.5									1.18					
1-Apr	8.29	28.0	23.9									1.32					
20-Apr	7.97	33.8	29.0		16,600			5,950	1,300			0.973				<MDL	1.50E+06

Sawdust Bulking Material Date	pH	Total Solids (mg/L)	Total Volatile Solids (mg/L)	NH_4-N (mg/kg)	TKN (mg/kg)	NO_3-N (mg/kg)	TP (mg/kg)	TP (mg/kg)	Micro Results Salmonellae (MPN/100g)	Fecal Coliform (MPN/100g)
3-Mar		38.1							<MDL	3.40E+05

Yard Waste Bulking Material Date	pH	Total Solids (mg/L)	Total Volatile Solids (mg/L)	NH_4-N (mg/kg)	TKN (mg/kg)	NO_3-N (mg/kg)	TP (mg/kg)	TP (mg/kg)	Micro Results Salmonellae (MPN/100g)	Fecal Coliform (MPN/100g)
3-Mar		39.4							5.1	7.60E+09

King County Environmental Lab Analytical Report

ʾROJECT: 423163-49

	Sample 1	Sample 2	Sample 3
Locator:	LRIMIX1	LRIMIX2	LRIMIX3
Descrip:	Off-site LRI compo	Off-site LRI compo	Off-site LRI compo
Client Loc:	2:1 Yardwaste to Centridry	4:1 Yardwaste to Centridry	3:1 Sawdust to Centridry
Sampled:	Apr 20, 98	Apr 20, 98	Apr 20, 98
Lab ID:	L13185-1	L13185-2	L13185-3
Matrix:	COMPOST	COMPOST	COMPOST
% Solids:	54.9	52.6	51

ʾarameters	Value	Qual	MDL - Dry Weight Basis	RDL	Units	Value	Qual	MDL - Dry Weight Basis	RDL	Units	Value	Qual	MDL - Dry Weight Basis	RDL	Units
:OMBINED LABS															
M.Code=Conventionals SM2540 B,M															
ɜulk Density	0.783		0.000018	0.0000364	g/ml	0.985		0.000019	0.000038	g/ml	0.557		0.00002	0.0000392	g/ml
M.Code=Conventionals SM2540-G															
ꞌotal Solids *	54.9		0.005	0.01	%	52.6		0.005	0.01	%	51		0.005	0.01	%
ꞌotal Volatile Solids *	27.9		0.005	0.01	%	26.4		0.005	0.01	%	40.1		0.005	0.01	%
M.Code=Conventionals SM4500-H-B															
ɔH *	8.05				pH	7.94				pH	8.14				pH
M.Code=Conventionals SM4500-N-B															
ꞌotal Kjeldahl Nitrogen	29100		9.1		mg/Kg	24700		9.5		mg/Kg	23500		9.8		mg/Kg
M.Code=Conventionals SM4500-NH3-H															
ʌmmonia Nitrogen	2640		0.91	1.82	mg/Kg	1710		0.95	1.9	mg/Kg	3670		0.98	1.96	mg/Kg
M.Code=Conventionals SM4500-P-B,E															
ꞌotal Phosphorus	2170		0.24	0.455	mg/Kg	3840		0.25	0.475	mg/Kg	5430		0.25	0.49	mg/Kg
M.Code=Metals METRO 16-01-005															
ʌercury, Total, CVAA	1.32		0.062	0.619	mg/Kg	1.05		0.076	0.764	mg/Kg	1.47		0.076	0.761	mg/Kg
M.Code=Metals METRO 16-02-004															
:admium, Total, ICP	4.13		0.27	1.38	mg/Kg	4.05		0.29	1.43	mg/Kg	4.67		0.29	1.49	mg/Kg
:hromium, Total, ICP	38.4		0.46	2.3	mg/Kg	38.6		0.48	2.4	mg/Kg	31.2		0.49	2.49	mg/Kg
:opper, Total, ICP	404		0.36	1.84	mg/Kg	384		0.38	1.9	mg/Kg	453		0.39	1.98	mg/Kg
.ead, Total, ICP	48.5		2.7	13.8	mg/Kg	54.4		2.9	14.3	mg/Kg	39		2.9	14.9	mg/Kg
ʌickel, Total, ICP	23.3		1.8	9.18	mg/Kg	23.2		1.9	9.54	mg/Kg	18.9		2	9.94	mg/Kg
ʾotassium, Total, ICP	3700		180	918	mg/Kg	4870		190	954	mg/Kg	1650		200	994	mg/Kg
ːinc, Total, ICP	386		0.46	2.3	mg/Kg	378		0.48	2.4	mg/Kg	388		0.49	2.49	mg/Kg
M.Code=Metals METRO 16-04-001															
ʌrsenic, Total, ICP-MS	7.18		0.22	0.898	mg/Kg	8.48		0.23	0.939	mg/Kg	4.59		0.25	0.982	mg/Kg
ʌolybdenum, Total, ICP-MS	4.32		0.22	0.898	mg/Kg	4.35		0.23	0.939	mg/Kg	6.61		0.25	0.982	mg/Kg
ɜelenium, Total, ICP-MS	2.93		0.46	2.24	mg/Kg	2.53		0.48	2.36	mg/Kg	3.2		0.49	2.45	mg/Kg
M.Code=Micros METRO MC MM Sec.7															
ɜalmonellae		<MDL	4		MPN/100g		<MDL	4		MPN/100g		<MDL	4		MPN/100g
M.Code=Micros METRO MC SOP 6.1.3															
ꞌecal Coliform	2400000				MPN/100g	15000000				MPN/100g		<MDL	40		MPN/100g

ʾ Not converted to dry weight basis for
:his parameter

King County Environmental Lab Analytical Report

PROJECT: 423163-49

Locator:	LRIMIX4
Descrip:	Off-site LRI compo
Client Loc:	3:1 Sawdust to Dewatered Cake
Sampled:	Apr 20, 98
Lab ID:	L13185-4
Matrix:	COMPOST
% Solids:	33.8

Parameters	Value	Qual	MDL - Dry Weight Basis	RDL	Units
COMBINED LABS					
M.Code=Conventionals SM2540 B,M					
Bulk Density	0.973		0.00003	0.0000592	g/ml
M.Code=Conventionals SM2540-G					
Total Solids *	33.8		0.005	0.01	%
Total Volatile Solids *	29		0.005	0.01	%
M.Code=Conventionals SM4500-H-B					
pH *	7.97				pH
M.Code=Conventionals SM4500-N-B					
Total Kjeldahl Nitrogen	16600		15		mg/Kg
M.Code=Conventionals SM4500-NH3-H					
Ammonia Nitrogen	2740		1.5	2.96	mg/Kg
M.Code=Conventionals SM4500-P-B,E					
Total Phosphorus	5950		0.38	0.74	mg/Kg
M.Code=Metals METRO 16-01-005					
Mercury, Total, CVAA	1.1	<RDL	0.12	1.15	mg/Kg
M.Code=Metals METRO 16-02-004					
Cadmium, Total, ICP	2.76		0.44	2.2	mg/Kg
Chromium, Total, ICP	20.6		0.74	3.67	mg/Kg
Copper, Total, ICP	285		0.59	2.93	mg/Kg
Lead, Total, ICP	26.4		4.4	22	mg/Kg
Nickel, Total, ICP	12	<RDL	2.9	14.6	mg/Kg
Potassium, Total, ICP	1300	<RDL	290	1460	mg/Kg
Zinc, Total, ICP	245		0.74	3.67	mg/Kg
M.Code=Metals METRO 16-04-001					
Arsenic, Total, ICP-MS	3.11		0.36	1.47	mg/Kg
Molybdenum, Total, ICP-MS	4.47		0.36	1.47	mg/Kg
Selenium, Total, ICP-MS	2.2	<RDL	0.74	3.67	mg/Kg
M.Code=Micros METRO MC MM Sec.7					
Salmonellae		<MDL	6		MPN/100g
M.Code=Micros METRO MC SOP 6.1.3					
Fecal Coliform	1500000				MPN/100g

* Not converted to dry weight basis for this parameter

King County Environmental Lab Analytical Report

PROJECT: 423163-49

Locator:	LRIMIX1	LRIMIX2	LRIMIX3
Descrip:	Off-site LRI compo	Off-site LRI compo	Off-site LRI compo
Client Loc:	2:1 Centridry:Yard Waste	4:1 Yard Waste to Centridry	2:1 Sawdust:Centridry
Sampled:	Apr 01, 98	Apr 01, 98	Apr 01, 98
Lab ID:	L12981-1	L12981-2	L12981-3
Matrix:	COMPOST	COMPOST	COMPOST
% Solids:	43.9	42.4	35.6

Parameters	Value	Qual	MDL - Dry Weight Basis	RDL	Units	Value	Qual	MDL - Dry Weight Basis	RDL	Units	Value	Qual	MDL - Dry Weight Basis	RDL	Units
CONVENTIONALS															
M.Code=Conventionals SM2540 B,M															
Bulk Density	1.08		0.000023	0.0000456	g/ml	1.33		0.000024	0.0000472	g/ml	1.06		0.000028	0.0000562	g/ml
M.Code=Conventionals SM2540-G															
Total Solids *	43.9		0.005	0.01	%	42.4		0.005	0.01	%	35.6		0.005	0.01	%
Total Volatile Solids *	25.3		0.005	0.01	%	21.2		0.005	0.01	%	27.8		0.005	0.01	%
M.Code=Conventionals SM4500-H-B															
pH *	7.7				pH	8.3				pH	8.25				pH

* Not converted to dry weight basis for this parameter

King County Environmental Lab Analytical Report

PROJECT: 423163-49

Locator: LRIMIX4
Descrip: Off-site LRI compo
Client Loc: 3:1 Sawdust:Dewatered Cake
Sampled: Apr 01, 98
Lab ID: L12981-4
Matrix: COMPOST
% Solids: 28

Parameters	Value	Qual	MDL - Dry Weight Basis	RDL	Units
CONVENTIONALS					
M.Code=Conventionals SM2540 B,M					
Bulk Density	1.32		0.000036	0.0000714	g/ml
M.Code=Conventionals SM2540-G					
Total Solids *	28		0.005	0.01	%
Total Volatile Solids *	23.9		0.005	0.01	%
M.Code=Conventionals SM4500-H-B					
pH *	8.29				pH

* Not converted to dry weight basis for this parameter

King County Environmental Lab Analytical Report

ROJECT: 423163-49

	LRIMIX1	LRIMIX2	LRIMIX3
Locator:	LRIMIX1	LRIMIX2	LRIMIX3
Descrip:	Off-site LRI compo	Off-site LRI compo	Off-site LRI compo
Client Loc:	2:1 Centridry to Yardwaste	4:1 Yardwaste to Centridry	3:1 Sawdust to Centridry
Sampled:	Mar 18, 98	Mar 18, 98	Mar 20, 98
Lab ID:	L12988-1	L12988-2	L12988-3
Matrix:	COMPOST	COMPOST	COMPOST
% Solids:	55.2	54.5	50.6

arameters	Value	Qual	MDL - Dry Weight Basis	RDL	Units	Value	Qual	MDL - Dry Weight Basis	RDL	Units	Value	Qual	MDL - Dry Weight Basis	RDL	Units
OMBINED LABS															
M.Code=Conventionals SM2540 B,M															
ulk Density	0.757		0.000018	0.0000362	g/ml	0.714		0.000018	0.0000367	g/ml	0.595		0.00002	0.0000395	g/ml
M.Code=Conventionals SM2540-G															
otal Solids *	55.2		0.005	0.01	%	54.5		0.005	0.01	%	50.6		0.005	0.01	%
otal Volatile Solids *	30.6		0.005	0.01	%	31.5		0.005	0.01	%	39.8		0.005	0.01	%
M.Code=Conventionals SM4500-H-B															
H *	8.5				pH	8.96				pH	8.68				pH
M.Code=Conventionals SM4500-N-B															
otal Kjeldahl Nitrogen															
M.Code=Conventionals SM4500-NH3-H															
mmonia Nitrogen															
M.Code=Conventionals SM4500-P-B,E															
otal Phosphorus															
M.Code=Metals METRO 16-02-004															
otassium, Total, ICP															
M.Code=Micros METRO MC MM Sec.7															
almonellae															
M.Code=Micros METRO MC SOP 6.1.3															
ecal Coliform															

Not converted to dry weight basis for his parameter

King County Environmental Lab Analytical Report

ROJECT: 423163-49

Locator: LRIMIX4
Descrip: Off-site LRI compo
Client Loc: 3:1 Sawdust to Dewatered Cake
Sampled: Mar 20, 98
Lab ID: L12988-4
Matrix: COMPOST
% Solids: 32.8

arameters	Value	Qual	MDL	RDL	Units
		- Dry Weight Basis			
OMBINED LABS					
M.Code=Conventionals SM2540 B,M					
ulk Density	1.18		0.00003	0.000061	g/ml
M.Code=Conventionals SM2540-G					
otal Solids *	32.8		0.005	0.01	%
otal Volatile Solids *	28.5		0.005	0.01	%
M.Code=Conventionals SM4500-H-B					
H *	8.57				pH
M.Code=Conventionals SM4500-N-B					
otal Kjeldahl Nitrogen					
M.Code=Conventionals SM4500-NH3-H					
mmonia Nitrogen					
M.Code=Conventionals SM4500-P-B,E					
'otal Phosphorus					
M.Code=Metals METRO 16-02-004					
'otassium, Total, ICP					
M.Code=Micros METRO MC MM Sec.7					
almonellae					
M.Code=Micros METRO MC SOP 6.1.3					
ecal Coliform					

Not converted to dry weight basis for
his parameter

King County Environmental Lab Analytical Report

LRI

PROJECT: 423163-49

	LRIMIX1	LRIMIX2	LRIMIX3
Locator:	LRIMIX1	LRIMIX2	LRIMIX3
Descrip:	Off-site LRI compo	Off-site LRI compo	Off-site LRI compo
Client Loc:	2:1 Centridry to Yard Waste	4:1 Yard Waste to Centridry	3:1 Sawdust to Centridry
Sampled:	Mar 03, 98	Mar 03, 98	Mar 03, 98
Lab ID:	L12919-1	L12919-2	L12919-3
Matrix:	COMPOST	COMPOST	COMPOST
% Solids:	49.8	45.6	44.5

Parameters	Value	Qual	MDL - Dry Weight Basis	RDL	Units	Value	Qual	MDL - Dry Weight Basis	RDL	Units	Value	Qual	MDL - Dry Weight Basis	RDL	Units
COMBINED LABS															
M.Code=Conventionals SM2540 B,M															
Bulk Density	0.791		0.00002	0.0000402	g/ml	0.787		0.000022	0.0000439	g/ml	0.631		0.000022	0.0000449	g/ml
M.Code=Conventionals SM2540-G															
Total Solids *	49.8		0.005	0.01	%	45.6		0.005	0.01	%	44.5		0.005	0.01	%
Total Volatile Solids *	30.8		0.005	0.01	%	27.3		0.005	0.01	%	34.4		0.005	0.01	%
M.Code=Conventionals SM4500-H-B															
pH *	7.69				pH	7.5				pH	8.04				pH
M.Code=Conventionals SM4500-N-B															
Total Kjeldahl Nitrogen	20100		10		mg/Kg	21900		11		mg/Kg	24700		11		mg/Kg
M.Code=Conventionals SM4500-NH3-H															
Ammonia Nitrogen	466		1	2.01	mg/Kg	346		1.1	2.19	mg/Kg	461		1.1	2.25	mg/Kg
M.Code=Conventionals SM4500-P-B,E															
Total Phosphorus	3350		0.26	0.502	mg/Kg	2960		0.29	0.548	mg/Kg	4520		0.29	0.562	mg/Kg
M.Code=Metals METRO 16-02-004															
Potassium, Total, ICP	3230		200	1010	mg/Kg	3750		220	1090	mg/Kg	1400		220	1130	mg/Kg
M.Code=Micros METRO MC MM Sec.7															
Salmonellae		<MDL	4		MPN/100g	4.4		4		MPN/100g		<MDL	4		MPN/100g
M.Code=Micros METRO MC SOP 6.1.3															
Fecal Coliform	460000000				MPN/100g	610000000				MPN/100g	29000000				MPN/100g

* Not converted to dry weight basis for this parameter

King County Environmental Lab Analytical Report

ROJECT: 423163-49

	Sample 1	Sample 2	Sample 3
Locator:	LRIMIX4	TEMP	TEMP
Descrip:	Off-site LRI compo	Temporary Locator	Temporary Locator
Client Loc:	3:1 Sawdust to Dewatered Cake	Yard Waste bulking material	Sawdust bulking material
Sampled:	Mar 03, 98	Mar 03, 98	Mar 03, 98
Lab ID:	L12919-4	L12919-5	L12919-6
Matrix:	COMPOST	OTHR SOLID	OTHR SOLID
% Solids:	30.5	39.4	38.1

arameters	Value	Qual	MDL - Dry Weight Basis	RDL	Units	Value	Qual	MDL - Dry Weight Basis	RDL	Units	Value	Qual	MDL - Dry Weight Basis	RDL	Units
OMBINED LABS															
M.Code=Conventionals SM2540 B,M															
ulk Density	1.37		0.000033	0.0000656	g/ml										
M.Code=Conventionals SM2540-G															
otal Solids *	30.5		0.005	0.01	%	39.4		0.005	0.01	%	38.1		0.005	0.01	%
otal Volatile Solids *	25.7		0.005	0.01	%										
M.Code=Conventionals SM4500-H-B															
H *	7.79				pH										
M.Code=Conventionals SM4500-N-B															
otal Kjeldahl Nitrogen	20300		16		mg/Kg										
M.Code=Conventionals SM4500-NH3-H															
mmonia Nitrogen	390		1.6	3.28	mg/Kg										
M.Code=Conventionals SM4500-P-B,E															
Total Phosphorus	2040		0.43	0.82	mg/Kg										
M.Code=Metals METRO 16-02-004															
otassium, Total, ICP	1300	<RDL	320	1620	mg/Kg										
M.Code=Micros METRO MC MM Sec.7															
almonellae		<MDL	7		MPN/100g	5.1		5		MPN/100g		<MDL	5		MPN/100g
M.Code=Micros METRO MC SOP 6.1.3															
ecal Coliform	9800000				MPN/100g	7.6E+09				MPN/100g	340000				MPN/100g

* Not converted to dry weight basis for this parameter

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126980-4-3940

King County WPCD Environmental Lab.
Subcontract Analysis Coordinator
322 W. Ewing Street MS LAB
Seattle WA 98119

COMPOST ANALYSIS Chemical

Date Received:	21 April 1998
Sample Identification:	P13185-1 LRIMAX-1
Sample Id. Number:	1/4-126980

Constituents:	Received %	Dry %	Interpretation: (for finished compost)	Dry Wt: Value	Quality Rating
Tot. Nitrogen (TN)	2.7	5.3	Nutrients (N+P2O5+K2O)	10	A
Organic N (Org-N)	2.4	4.7	Organic:Ash	1.1	A
Ammonia (NH3-N)	0.28	0.54	C:N Ratio ((OM/2)/N)	5	A
Nitrate (NO3-N)	0.000	0.000	pH Value	7.8	B
Phosphorus (P2O5)	2.1	4.2	AgIndex ((Nutrients)/(Na+Cl))	>10	A
Potassium (K2O)	0.24	0.47	Total Dissolved Salts (% w/w)	1.0	A
Calcium (Ca)	1.1	2.2	(EC X 640 = mg/L TDS)		
Magnesium (Mg)	0.24	0.46	Calcium:Magnesium Ratio	5	A
Sulfate (SO4-S)	0.053	0.10	Calcium (as CaCO3)(lb/Ton)	109	A
Chloride (Cl)	0.041	0.080	A=Good; B= Average; C= Caution		
Sodium (Na)	0.040	0.079	Application Rates may be limited by the following:		
Moisture	48.8	0.0			
Organic Matter	26.7	52.3	Nutrients for Crop requirement		
Ash	24.4	47.7	Toxins if un-cured compost		
Bulk Den. lb/cuft	37.7	19.3			
pH value (units)	7.8	X	Soil may require additional Magnesium		
EC(EC5w/w)mmhos	3.0	X			

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126980-4-3940

RESPIRATION RATE

Date Sample Received:	21 April 1998
Lab Number:	1/4-126980
Identification:	P13185-1 LRIMIX-1

SAMPLE REMOVED (% dry wt.)		TEST CONDITIONS	
Non-Compostable (> 4mm)	< 0.1	Temperature(deg C)	37
SAMPLE USED (% dry wt.)		Moisture Adj.	62% OM + 20% Ash
Total Solids	100.0	Add: Nutrients	Yes
Inorganic Matter	47.7	pH Adj.	Yes
Biodegradable Vol. Solids	52.3	Microbes	Yes

CO2 Production	Org. Fraction	CO2 Production	Total Solids
CO2 (mg/Kg-bvs/Hr)	709	CO2 (mg/KgHr)	371
CO2 (ml/Kg-bvs/Hr)	361	CO2 (ml/KgHr)	189
Carbon Depleted		Carbon Depleted	
C (mg/Kg-bvs/Hr)	193	C (mg/KgHr)	101
C (% C/day)	0.8		
Oxygen Consumed (from CO2 produced)		Oxygen Consumed (from CO2 produced)	
O2 (mg/Kg-bvs/Hr)	515	O2 (mg/KgHr)	269
O2 (ml/Kg-bvs/Hr)	361	O2 (ml/KgHr)	189

Rating: STABLE:
Odor production not likely; minimal impact on soil carbon and nitrogen dynamics; ready for most uses; may need curing.

USES: NOTE: Based on this test alone.
Improving agriculture soils

bvs = Biodegradable Volatile Solids

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126980-4-3940

Seed Germination and Root Elongation Bioassy

Date Received: 21 April 1998
Sample Identification: P13185-1 LRIMIX-1
Sample Id. Number: 1/4-126980

COMPOST		TEST		CONTROL	
pH value:	7.8	Seed:	Cress	Mean Control Germination	
Moisture %:	48.8	Temperature:	25	MCG =	98.0
Organic Matter %:	26.7	Incubation(Hours):	48	Mean Control Radicle Length	
Ash %	2.0	Dilution (X Sat.):	2.0	MCRL =	6.2

Data:	Mean Treat. Germination	Mean Treatment Radicle Length		Germination Index (GI)
Un-diluted Avg. 5 Reps.	84.0	2.8		0.4
3 X Dil. Avg. 5 Reps.	86.0	5.8		0.8
10 X Dil. Avg. 5 Reps.	98.0	6.7	Greater than	1.0
			Avg. GI	0.7

Interpretation:

GI	Rating	Characterstic
1.0-0.8	Very Mature	No phytotoxicity/No odor
0.8-0.6	Mature	Min.phytotoxicity/No odor
0.6-0.4	Immature	Phytotoxicity/Characteristic Odor
Less than 0.4	Very immature	Phytotoxicity/Strong Odor

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COMPOST ANALYSIS Chemical

Date Received:	21 April 1998
Sample Identification:	P13185-2 LRIMAX-2
Sample Id. Number:	2/4-126980

Constituents:	Received %	Dry %	Interpretation: (for finished compost)	Dry Wt: Value	Quality Rating
Tot. Nitrogen (TN)	2.7	4.2	Nutrients (N+P2O5+K2O)	7	A
Organic N (Org-N)	2.4	3.8	Organic:Ash	0.6	C
Ammonia (NH3-N)	0.23	0.36	C:N Ratio ((OM/2)/N)	5	A
Nitrate (NO3-N)	0.000	0.000	pH Value	7.8	B
Phosphorus (P2O5)	1.8	2.8	AgIndex ((Nutrients)/(Na+Cl))	>10	A
Potassium (K2O)	0.26	0.41	Total Dissolved Salts (% w/w)	0.8	A
Calcium (Ca)	0.90	1.4	(EC X 640 = mg/L TDS)		
Magnesium (Mg)	0.19	0.29	Calcium:Magnesium Ratio	5	A
Sulfate (SO4-S)	0.038	0.059	Calcium (as CaCO3)(lb/Ton)	70	A
Chloride (Cl)	0.041	0.064	A=Good; B= Average; C= Caution		
Sodium (Na)	0.035	0.055	Application Rates may be limited by the following:		
Moisture	35.8	0.0			
Organic Matter	25.1	39.1	Nutrients for Crop requirement		
Ash	39.0	60.9	Toxins if un-cured compost		
Bulk Den. lb/cuft	34.4	22.1			
pH value (units)	7.8	X	Soil may require additional Magnesium		
EC(EC5w/w)mmhos	2.4	X			

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126980-4-3940

RESPIRATION RATE

Date Sample Received:	21 April 1998
Lab Number:	2/4-126980
Identification:	P13185-2 LRIMIX-2

SAMPLE REMOVED (% dry wt.)		TEST CONDITIONS	
Non-Compostable (> 4mm)	< 0.1	Temperature(deg C)	37
SAMPLE USED (% dry wt.)		Moisture Adj.	62% OM + 20% Ash
Total Solids	100.0	Add: Nutrients	Yes
Inorganic Matter	60.9	pH Adj.	Yes
Biodegradable Vol. Solids	39.1	Microbes	Yes

CO2 Production	Org. Fraction	CO2 Production	Total Solids
CO2 (mg/Kg-bvs/Hr)	724	CO2 (mg/KgHr)	283
CO2 (ml/Kg-bvs/Hr)	369	CO2 (ml/KgHr)	144
Carbon Depleted		Carbon Depleted	
C (mg/Kg-bvs/Hr)	197	C (mg/KgHr)	77
C (% C/day)	0.8		
Oxygen Consumed (from CO2 produced)		Oxygen Consumed (from CO2 produced)	
O2 (mg/Kg-bvs/Hr)	526	O2 (mg/KgHr)	206
O2 (ml/Kg-bvs/Hr)	369	O2 (ml/KgHr)	144

Rating: STABLE:
Odor production not likely; minimal impact on soil carbon and nitrogen dynamics; ready for most uses; may need curing.
bvs = Biodegradable Volatile Solids

USES: NOTE: Based on this test alone.
Improving agriculture soils

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Attn: Richelle rose

126980-4-3940

Seed Germination and Root Elongation Bioassy

Date Received:	21 April 1998
Sample Identification:	P13185-2 LRIMIX-2
Sample Id. Number:	2/4-126980

COMPOST		TEST		CONTROL	
pH value:	7.8	Seed:	Cress	Mean Control Germination	
Moisture %:	35.8	Temperature:	25	MCG =	98.0
Organic Matter %:	25.1	Incubation(Hours):	48	Mean Control Radicle Length	
Ash %	2.0	Dilution (X Sat.):	2.0	MCRL =	6.2

Data:	Mean Treat. Germination	Mean Treatment Radicle Length		Germination Index (GI)
Un-diluted Avg. 5 Reps.	94.0	4.8		0.7
3 X Dil. Avg. 5 Reps.	94.0	6.6	Greater than	1.0
10 X Dil. Avg. 5 Reps.	98.0	6.5	Greater than	1.0
			Avg. GI	0.9

Interpretation:

GI	Rating	Characterstic
1.0-0.8	Very Mature	No phytotoxicity/No odor
0.8-0.6	Mature	Min.phytotoxicity/No odor
0.6-0.4	Immature	Phytotoxicity/Characteristic Odor
Less than 0.4	Very immature	Phytotoxicity/Strong Odor

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COMPOST ANALYSIS Chemical

Date Received: 21 April 1998
Sample Identification: P13185-3 LRIMAX-3
Sample Id. Number: 3/4-126980

Constituents:	Received %	Dry %	Interpretation: (for finished compost)	Dry Wt: Value	Quality Rating
Tot. Nitrogen (TN)	2.1	4.8	Nutrients (N+P2O5+K2O)	8	A
Organic N (Org-N)	1.7	3.8	Organic:Ash	3.7	A
Ammonia (NH3-N)	0.43	0.97	C:N Ratio ((OM/2)/N)	8	A
Nitrate (NO3-N)	0.000	0.000	pH Value	8.1	C
Phosphorus (P2O5)	1.5	3.4	AgIndex ((Nutrients)/(Na+Cl))	>10	A
Potassium (K2O)	0.09	0.20	Total Dissolved Salts (% w/w)	1.0	A
Calcium (Ca)	0.76	1.7	(EC X 640 = mg/L TDS)		
Magnesium (Mg)	0.13	0.30	Calcium:Magnesium Ratio	6	B
Sulfate (SO4-S)	0.071	0.16	Calcium (as CaCO3)(lb/Ton)	85	A
Chloride (Cl)	0.030	0.067	A=Good; B= Average; C= Caution		
Sodium (Na)	0.036	0.082	Application Rates may be limited by the following:		
Moisture	55.4	0.0			
Organic Matter	35.1	78.8	Nutrients for Crop requirement		
Ash	9.4	21.2	pH of soil and/or toxins if un-cured compost		
Bulk Den. lb/cuft	34.6	15.4			
pH value (units)	8.1	X	Soil may require additional Magnesium		
EC(EC5w/w)mmhos	3.2	X			

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126980-4-3940

RESPIRATION RATE

Date Sample Received: 21 April 1998
Lab Number: 3/4-126980
Identification: P13185-3 LRIMIX-3

SAMPLE REMOVED (% dry wt.)		TEST CONDITIONS	
Non-Compostable (> 4mm)	< 0.1	Temperature(deg C)	37
SAMPLE USED (% dry wt.)		Moisture Adj.	62% OM + 20% Ash
Total Solids	100.0	Add: Nutrients	Yes
Inorganic Matter	21.2	pH Adj.	Yes
Biodegradable Vol. Solids	78.8	Microbes	Yes

CO2 Production	Org. Fraction	CO2 Production	Total Solids
CO2 (mg/Kg-bvs/Hr)	1008	CO2 (mg/KgHr)	794
CO2 (ml/Kg-bvs/Hr)	513	CO2 (ml/KgHr)	404
Carbon Depleted		Carbon Depleted	
C (mg/Kg-bvs/Hr)	275	C (mg/KgHr)	217
C (% C/day)	1.2		
Oxygen Consumed (from CO2 produced)		Oxygen Consumed (from CO2 produced)	
O2 (mg/Kg-bvs/Hr)	733	O2 (mg/KgHr)	577
O2 (ml/Kg-bvs/Hr)	513	O2 (ml/KgHr)	404

Rating: MODERATELY UN-STABL
Moving past active phase; uncured; soil applied may result in N immobilization/ toxicity; use with caution.

USES: NOTE: Based on this test alone.
Mulch and green manures

bvs = Biodegradable Volatile Solids

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COMPOST ANALYSIS Chemical

Date Received:	21 April 1998
Sample Identification:	P13185-4 LRIMAX-4
Sample Id. Number:	4/4-126980

Constituents:	Received %	Dry %	Interpretation: (for finished compost)	Dry Wt: Value	Quality Rating
Tot. Nitrogen (TN)	1.2	3.6	Nutrients (N+P2O5+K2O)	6	A
Organic N (Org-N)	0.93	2.9	Organic:Ash	5.8	A
Ammonia (NH3-N)	0.23	0.72	C:N Ratio ((OM/2)/N)	12	A
Nitrate (NO3-N)	0.000	0.000	pH Value	7.6	B
Phosphorus (P2O5)	0.71	2.2	AgIndex ((Nutrients)/(Na+Cl))	>10	A
Potassium (K2O)	0.053	0.16	Total Dissolved Salts (% w/w)	0.7	A
Calcium (Ca)	0.36	1.1	(EC X 640 = mg/L TDS)		
Magnesium (Mg)	0.062	0.19	Calcium:Magnesium Ratio	6	B
Sulfate (SO4-S)	0.061	0.19	Calcium (as CaCO3)(lb/Ton)	55	A
Chloride (Cl)	0.025	0.077	A=Good; B= Average; C= Caution		
Sodium (Na)	0.025	0.078	Application Rates may be limited by the following:		
Moisture	67.6	0.0			
Organic Matter	27.6	85.2	Nutrients for Crop requirement		
Ash	4.8	14.8	Toxins if un-cured compost		
Bulk Den. lb/cuft	39.9	12.9			
pH value (units)	7.6	X	Soil may require additional Magnesium		
EC(EC5w/w)mmhos	2.3	X			

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126980-4-3940

Seed Germination and Root Elongation Bioassy

Date Received: 21 April 1998
Sample Identification: P13185-3 LRIMIX-3
Sample Id. Number: 3/4-126980

COMPOST		TEST		CONTROL	
pH value:	8.1	Seed:	Cress	Mean Control Germination	
Moisture %:	55.4	Temperature:	25	MCG =	98.0
Organic Matter %:	35.1	Incubation(Hours):	48	Mean Control Radicle Length	
Ash %	2.0	Dilution (X Sat.):	2.0	MCRL =	6.2

Data:	Mean Treat. Germination	Mean Treatment Radicle Length		Germination Index (GI)
Un-diluted				
Avg. 5 Reps.	98.0	3.8		0.6
3 X Dil.				
Avg. 5 Reps.	94.0	5.4		0.8
10 X Dil.				
Avg. 5 Reps.	96.0	6.6	Greater than	1.0
			Avg. GI	0.8

Interpretation:

GI	Rating	Characterstic
1.0-0.8	Very Mature	No phytotoxicity/No odor
0.8-0.6	Mature	Min.phytotoxicity/No odor
0.6-0.4	Immature	Phytotoxicity/Characteristic Odor
Less than 0.4	Very immature	Phytotoxicity/Strong Odor

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126980-4-3940

RESPIRATION RATE

Date Sample Received:	21 April 1998
Lab Number:	4/4-126980
Identification:	P13185-4 LRIMIX-4

SAMPLE REMOVED (% dry wt.)		TEST CONDITIONS	
Non-Compostable (> 4mm)	< 0.1	Temperature(deg C)	37
SAMPLE USED (% dry wt.)		Moisture Adj.	62% OM + 20% Ash
Total Solids	100.0	Add: Nutrients	Yes
Inorganic Matter	14.8	pH Adj.	Yes
Biodegradable Vol. Solids	85.2	Microbes	Yes

CO2 Production	Org. Fraction	CO2 Production	Total Solids
CO2 (mg/Kg-bvs/Hr)	145	CO2 (mg/KgHr)	123
CO2 (ml/Kg-bvs/Hr)	74	CO2 (ml/KgHr)	63
Carbon Depleted		Carbon Depleted	
C (mg/Kg-bvs/Hr)	39	C (mg/KgHr)	34
C (% C/day)	0.2		
Oxygen Consumed (from CO2 produced)		Oxygen Consumed (from CO2 produced)	
O2 (mg/Kg-bvs/Hr)	105	O2 (mg/KgHr)	90
O2 (ml/Kg-bvs/Hr)	74	O2 (ml/KgHr)	63

Rating: VERY STABLE:
Mature compost; well aged; possibly over-aged like soil; Ready for most uses.

USES: NOTE: Based on this test alone.
Growing medium with/without additional blending
Formulating growing medium for potted crops
Top dressing turf. Landscape planting.

bvs = Biodegradable Volatile Solids

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126980-4-3940

Seed Germination and Root Elongation Bioassy

Date Received: 21 April 1998
Sample Identification: P13185-4 LRIMIX-4
Sample Id. Number: 4/4-126980

COMPOST		TEST		CONTROL	
pH value:	7.6	Seed:	Cress	Mean Control Germination	
Moisture %:	67.6	Temperature:	25	MCG =	98.0
Organic Matter %:	27.6	Incubation(Hours):	48	Mean Control Radicle Length	
Ash %	2.0	Dilution (X Sat.):	2.0	MCRL =	6.2

Data:	Mean Treat. Germination	Mean Treatment Radicle Length		Germination Index (GI)
Un-diluted Avg. 5 Reps.	90.0	6.3		0.9
3 X Dil. Avg. 5 Reps.	96.0	4.9		0.8
10 X Dil. Avg. 5 Reps.	100.0	7.5	Greater than	1.0
			Avg. GI	0.9

Interpretation:

GI	Rating	Characterstic
1.0-0.8	Very Mature	No phytotoxicity/No odor
0.8-0.6	Mature	Min.phytotoxicity/No odor
0.6-0.4	Immature	Phytotoxicity/Characteristic Odor
Less than 0.4	Very immature	Phytotoxicity/Strong Odor

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126980-4-3940

Report

Date Received:	21 April 1998
Sample Identification:	P13185 1-4 LRIMIX 1-4
Sample Id. Number:	1/4-4/4-126980

Cation Exchange Capacity

P13185 - 1 LRIMIX - 1	58	meq/100g
P13185 - 2 LRIMIX - 2	52	meq/100g
P13185 - 3 LRIMIX - 3	51	meq/100g
P13185 - 4 LRIMIX - 4	39	meq/100g

x

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
3	03/03/98	14.9	19.1	03/07/98	03/18/98	132863

Comments: Yard Waste to Centradry 4 to 1 a total of 17.7 tons

Date	Time	Temperature in C.	CFM'S
03/03/98			
	1700	20.1	0.0
	2300	39.1	0,0
03/04/98			
	0500	55.8	0.0
	1100	58.8	179.0
	1700	57.1	0.0
	2300	58.6	0.0
03/05/98			
	0500	61.4	0.0
	1100	56.8	0.0
	1700	59.9	56.8
	2300	59.7	44.0
03/06/98			
	0500	58.1	0.0
	1100	61.0	104.0
	1700	60.3	132.0
	2300	58.8	77.5
3/07/98			
	0500	61.0	60.9
	1100	58.1	44.3
	1700	60.3	46.8
	2300	58.8	50.5
03/08/98			
	0500	58.8	30.9
	1100	61.6	85.4
	1700	58.4	38.7
	2300	61.0	45.4
03/09/98			
	0500	57.5	91.9
	1100	60.1	38.0
	1700	57.9	37.7
	2300	60.1	31.7
03/10/98			
	0500	57.5	31.7
	1100	59.7	29.2
	1700	59.9	32.9
	2300	58.1	0.0
03/11/98			
	0500	59.4	24.9
	1100	60.3	39.0
	1700	60.5	59.6
	2300	58.4	40.0
03/12/98			

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
3	03/03/98	14.9	19.1	03/07/98	03/18/98	132863

Comments: Yard Waste to Centradry 4 to 1 a total of 17.7 tons

Date	Time	Temperature in C.	CFM'S
03/12/98			
	0500	59.9	40.6
	1100	46.3	27.3
	1700	51.9	25.4
	2300	59.9	102.0
03/13/98			
	0500	63.3	105.0
	1100	59.9	21.5
	1700	60.3	134.0
	2300	59.9	124.0
03/14/98			
	0500	59.7	42.8
	1100	59.9	43.1
	1700	60.1	37.3
	2300	59.9	39.0
03/15/98			
	0500	59.7	34.4
	1100	59.9	68.9
	1700	60.3	55.4
	2300	60.3	0.0
03/16/98			
	0500	60.1	18.3
	1100		191.0
		71.8	
	1700	53.8	23.3
	2300	55.3	0.0
03/17/98			
	0500	56.2	170.0
	1100	51.9	11.4
	1700	46.0	25.9
	2300	41.9	0.0
03/18/98			
	0500	39.3	0.0
	1100	41.1	25.4
	1700	52.3	40.3
	2300	66.8	0.0
03/19/98			
	0500	45.4	0.0
	1100	36.3	0.0
	1700	36.3	112.0
	2300	59.0	0.0
03/20/98			
	0500	59.0	0.0
	1100	38.7	129.0

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
3	03/03/98	14.9	19.1	03/07/98	03/18/98	132863

Comments: Yard Waste to Centradry 4 to 1 a total of 17.7 tons

Date	Time	Temperature in C.	CFM'S
04/06/98			
	1830	11.5	87.6
04/07/98			
	0030	13.0	22.7
	0630	12.8	73.6
	1330	11.7	63.8
	1930	20.8	5.1
04/08/98			
	0130	12.1	0.0
	0730	10.2	5.1
	1330	18.2	19.7
	1930	5.6	180.0
04/09/98			
	0130	5.6	178.0
	0730	5.8	177.0
	1330	6.3	181.0
	1930	6.5	179.0
4/10/98			
	0130	7.3	179.0
	0730	9.1	178.0
	1330	11.2	181.0
	1930	12.1	180.0
04/11/98			
	0130	13.4	177.0
	0730	15.3	177.0
	1330	27.2	182.0
	1930	24.0	181.0
04/12/98			
	0130	31.1	175.0
	0730	43.0	176.0
	1330	54.5	184.0
	1930	0.0	180.0
04/13/98			
	0130	0.0	177.0
	0730	0.0	177.0
04/14/98			
	1630	0.0	184.0
	2230	0.0	178.0
04/15/98			
	0430	55.8	179.0
	0700	57.3	176.0
	0900	57.9	177.0
	1100	53.6	181.0
	1400	54.3	185.0

add 5% water to weight

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
3	03/03/98	14.9	19.1	03/07/98	03/18/98	132863

Comments: Yard Waste to Centradry 4 to 1 a total of 17.7 tons

Date	Time	Temperature in C.	CFM'S
04/15/98			
	2000	56.4	182.0
04/16/98			
	0200	58.8	179.0
	0800	59.7	178.0
	1400	60.3	259.0
	2000	46.9	181.0
04/17/98			
	0200	39.1	178.0
	0800	28.5	178.0
	1400	22.5	186.0
	2000	19.7	208.0
04/18/98			
	0200	19.7	177.0
	0800	19.0	178.0
	1400	15.1	278.0
	2000	14.3	181.0
04/19/98			
	0200	17.1	177.0
	0800	17.7	178.0
	1400	10.6	0.0
	2000	12.3	0.0
04/20/98			
	0200	9.9	0.0

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
2	03/03/98	18.2	27.5	03/07/98	03/18/98	139227

Comments: Yard Waste to Centradry 2 to 1 ratio total of 18.8 tons

Date	Time	Temperature in C.	CFM'S
03/03/98			
	1500	18.6	41.9
	2100	35.7	22.7
03/04/98			
	0300	50.8	227.0
	0900	66.4	186.0
	1500	58.8	110.0
	2100	60.3	127.0
03/05/98			
	0300	60.5	262.0
	0900	58.8	70.5
	1500	61.0	294.0
	2100	58.4	43.7
03/06/98			
	0300	56.4	206.0
	0900	53.4	22.7
	1500	57.3	33.3
	2100	56.8	16.1
3/07/98			
	0300	57.1	120.0
	0900	59.4	22.1
	1500	69.4	147.0
	2100	58.1	57.9
03/08/98			
	0300	58.6	89.2
	0900	58.6	23.3
	1500	59.7	163.0
	2100	58.6	160.0
03/09/98			
	0300	60.5	151.0
	0900	57.3	22.7
	1500	60.5	23.8
	2100	55.1	145.0
03/10/98			
	0300	57.5	21.5
	0900	57.9	18.3
	1500	59.7	19.0
	2100	65.5	67.2
03/11/98			
	0300	67.4	68.3
	0900	57.9	106.0
	1500	57.9	142.0
	2100	51.7	32.1
03/12/98			

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
2	03/03/98	18.2	27.5	03/07/98	03/18/98	139227

Comments: Yard Waste to Centradry 2 to 1 ratio total of 18.8 tons

Date	Time	Temperature in C.	CFM'S
03/12/98			
	0300	60.5	16.8
	0900	5.0	40.0
	1500	49.9	182.0
	2100	61.6	113.0
03/13/98			
	0300	67.9	161.0
	0900	63.5	206.0
	1500	57.3	33.3
	2100	56.4	33.3
03/14/98			
	0300	60.1	23.8
	0900	57.9	172.0
	1500	58.6	38.3
	2100	56.4	34.8
03/15/98			
	0300	53.4	218.0
	0900	51.0	34.8
	1500	49.3	41.6
	2100	48.4	240.0
03/16/98			
	0300	48.4	16.1
	0900	47.6	29.6
	1500	46.3	44.0
	2100	45.0	231.0
03/17/98			
	0300	44.3	28.3
	0900	42.8	31.7
	1500	46.0	30.5
	2100	54.5	37.0
03/18/98			
	0300	62.7	289.0
	0900	57.1	51.5
	1500	29.0	39.0
	2100	44.3	32.9
03/19/98			
	0300	66.1	246.0
	0900	59.7	252.0
	1500	60.3	14.4
	2100	60.5	26.4
3/20/98			
	0300	62.7	5.1
	0900	59.4	132.0
	1500	56.8	24.9

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
2	03/03/98	18.2	27.5	03/07/98	03/18/98	139227

Comments: Yard Waste to Centradry 2 to 1 ratio total of 18.8 tons

Date	Time	Temperature in C.	CFM'S
03/20/98			
	2100	56.4	26.9
03/21/98			
	0300	57.3	10.2
	0900	60.3	27.8
	1500	59.0	40.0
	2100	59.0	29.6
03/22/98			
	0300	59.7	32.5
	0900	59.0	16.8
	1500	58.4	26.4
	2100	57.5	23.3
03/23/98			
	0300	57.9	0.0
	0900	58.1	19.7
	1500	56.4	48.7
	2100	53.2	86.5
03/24/98			
	0300	50.6	65.8
	0900	47.8	50.0
	1500	45.0	42.8
	2100	42.8	298.0
03/25/98			
	0300	41.1	44.8
	0900	39.8	57.2
	1500	38.7	33.7
	2100	37.6	34.8
03/26/98			
	0300	36.5	44.6
	0900	35.2	49.2
	1500	32.4	33.3
	2100	28.5	40.3
03/27/98			
	0300	25.3	39.0
	0900	22.3	38.3
	1500	19.2	51.8
	2100	16.9	40.3
03/28/98			
	0300	14.3	44.8
	0900	12.3	37.3
	1500	10.8	41.9
	2100	9.3	45.7
03/29/98			
	0300	7.8	27.8

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
2	03/03/98	18.2	27.5	03/07/98	03/18/98	139227

Comments: Yard Waste to Centradry 2 to 1 ratio total of 18.8 tons

Date	Time	Temperature in C.	CFM'S
03/29/98			
	0900	6.5	37.3
	1500	5.8	44.6
	2100	5.2	51.8
03/30/98			
	0300	4.5	31.7
	0900	3.9	28.7
	1530	3.7	32.5
	2130	3.2	49.5
03/31/98			
	0330	3.0	44.6
	0930	3.0	23.8
	1530	3.0	46.8
	2130	3.0	30.0
04/01/98			
	0330	3.0	28.7
	0930	3.0	30.9
	1530	3.0	34.4
	2130	3.0	31.7
04/02/98			
	0330	3.0	21.5
	0930	3.0	0.0
	1530	3.2	61.8
	2130	3.2	75.1
04/03/98			
	0330	3.0	61.1
	0930	3.0	44.0
	1530	3.0	36.6
	2130	3.0	78.7
04/04/98			
	0330	3.0	54.0
	0930	3.0	42.2
	1530	3.2	79.1
	2130	3.2	45.4
04/05/98			
	0430	3.5	42.5
	1030	3.5	0.0
	1630	3.9	64.2
	2230	3.9	65.4
04/06/98			
	0430	3.7	75.3
	1030	3.9	57.0
	1630	4.1	47.6
	2230	4.1	65.2

Started to lose temp, re-mixed pile to get the temperature back up.

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
2	03/03/98	18.2	27.5	03/07/98	03/18/98	139227

Comments: Yard Waste to Centradry 2 to 1 ratio total of 18.8 tons

Date	Time	Temperature in C.	CFM'S
04/06/98			
04/07/98			
	0430	3.9	41.2
	1130	4.1	38.7
	1730	4.1	51.3
	2330	4.1	70.0
04/08/98			
	0530	4.1	30.0
	1130	6.9	51.8
	1730	12.3	37.3
	2330	17.3	49.2
04/09/98			
	0530	21.0	35.5
	1130	25.7	49.0
	1730	32.6	337.0
	2330	42.8	52.8
04/10/98			
	0530	53.0	58.1
	1130	59.9	40.0
	1730	59.9	60.3
	2330	59.4	35.5
04/11/98			
	0530	60.1	57.0
	1130	60.1	54.7
	1730	59.9	55.6
	2330	60.1	50.3
04/12/98			
	0530	59.7	30.5
	1130	60.3	41.2
	1730	0.0	75.1
	2330	0.0	280.0
04/13/98			
	0530	0.0	45.1
04/14/98			
	1430	0.0	41.2
	2030	0.0	51.3
04/15/98			
	0230	58.8	59.2
	0600	0.0	0.0
	0800	0.0	0.0
	1000	0.0	0.0
	1200	0.0	0.0
	1800	56.4	53.5
04/16/98	0000	54.7	58.3

power outage
Lost Data

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
2	03/03/98	18.2	27.5	03/07/98	03/18/98	139227

Comments: Yard Waste to Centradry 2 to 1 ratio total of 18.8 tons

Date	Time	Temperature in C.	CFM'S
04/16/98			
	0600	53.2	66.4
	1200	51.4	48.7
	1800	50.6	59.9
04/17/98	0000	49.1	108.0
	0600	47.6	45.1
	1200	46.0	40.6
	1800	45.0	59.9
04/18/98	0000	44.3	72.3
	0600	43.0	76.7
	1200	41.9	284.0
	1800	41.1	60.1
04/19/98	0000	40.2	91.9
	0600	39.3	47.9
	1200	38.7	51.3
	1800	37.6	0.0
04/20/98	0000	36.7	0.0

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
5	03/03/98	17.1	28.1	03/07/98	03/18/98	115137

Comments: Saw Dust to Centra dry 3 to 1 ratio for a total of 13.2 tons

Date	Time	Temperature in C.	CFM'S
03/03/98			
	1700	17.7	67.7
	2300	32.2	75.0
03/04/98			
	0500	60.1	45.7
	1100	60.1	34.1
	1700	59.9	65.4
	2300	61.4	72.2
03/05/98			
	0500	58.8	28.3
	1100	59.4	54.2
	1700	58.8	57.0
	2300	60.3	61.1
03/06/98			
	0500	60.3	56.5
	1100	60.3	57.0
	1700	60.3	58.3
	2300	60.3	67.9
3/07/98			
	0500	59.4	77.3
	1100	60.3	83.9
	1700	59.7	86.3
	2300	59.7	86.8
03/08/98			
	0500	60.3	131.0
	1100	59.0	142.0
	1700	59.9	135.0
	2300	60.3	125.0
03/09/98			
	0500	59.7	124.0
	1100	60.3	74.3
	1700	60.1	129.0
	2300	59.9	92.2
03/10/98			
	0500	60.1	137.0
	1100	59.0	91.0
	1700	60.3	159.0
	2300	59.9	121.0
03/11/98			
	0500	60.3	110.0
	1100	58.8	180.0
	1700	43.2	130.0
	2300	53.6	193.0
03/12/98			

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
5	03/03/98	17.1	28.1	03/07/98	03/18/98	115137

Comments: Saw Dust to Centra dry 3 to 1 ratio for a total of 13.2 tons

Date	Time	Temperature in C.	CFM'S
03/12/98			
	0500		114.0
		74.1	
	1100	66.6	175.0
	1700	64.8	211.0
	2300	57.9	165.0
03/13/98			
	0500	60.3	158.0
	1100	60.3	44.0
	1700	59.9	34.1
	2300	60.5	13.4
03/14/98			
	0500	60.3	27.3
	1100	59.4	30.0
	1700	60.3	45.1
	2300	59.9	47.9
03/15/98			
	0500	59.9	22.7
	1100	59.9	47.9
	1700	60.3	40.6
	2300	60.1	37.7
03/16/98			
	0500	59.9	55.8
	1100	60.3	32.5
	1700	60.3	54.0
	2300	59.9	48.2
03/17/98			
	0500	59.9	45.7
	1100	60.5	51.8
	1700	60.3	56.1
	2300	60.1	46.0
03/18/98			
	0500	59.9	51.0
	1100	56.4	38.3
	1700	28.3	43.4
	2300	17.1	24.3
03/19/98			
	0500	14.5	16.1
	1100	11.5	37.0
	1700	9.7	5.1
	2300	11.7	0.0
03/20/98			
	0500	13.8	0.0
	1100	22.5	0.0

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
5	03/03/98	17.1	28.1	03/07/98	03/18/98	115137

Comments: Saw Dust to Centra dry 3 to 1 ratio for a total of 13.2 tons

Date	Time	Temperature in C.	CFM'S
03/20/98			
	1700	38.7	0.0
	2300	46.7	0.0
03/21/98			
	0500	56.4	0.0
	1100	68.7	0.0
	1700	57.9	0.0
	2300	60.5	0.0
03/22/98			
	0500	59.9	0.0
	1100	59.9	0.0
	1700	60.3	0.0
	2300	59.9	0.0
03/23/98			
	0500	60.1	0.0
	1100	60.5	0.0
	1700	60.1	0.0
	2300	59.9	0.0
03/24/98			
	0500	58.6	0.0
	1100	56.6	0.0
	1700	54.9	26.4
	2300	53.0	0.0
03/25/98			
	0500	51.0	38.3
	1100	49.9	30.5
	1700	48.6	0.0
	2300	49.1	0.0
03/26/98			
	0500	49.5	0.0
	1100	49.7	36.6
	1700	49.3	19.7
	2300	49.1	36.3
03/27/98			
	0500	48.6	30.9
	1100	47.8	24.9
	1700	47.6	0.0
	2300	46.5	35.9
03/28/98			
	0500	46.5	0.0
	1100	45.0	31.3
	1700	45.0	28.3
	2300	43.9	39.0
03/29/98			

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
5	03/03/98	17.1	28.1	03/07/98	03/18/98	115137

Comments: Saw Dust to Centra dry 3 to 1 ratio for a total of 13.2 tons

Date	Time	Temperature in C.	CFM'S
03/29/98			
	0500	43.4	0.0
	1100	42.8	28.3
	1700	42.6	15.2
	2300	41.3	19.0
03/30/98			
	0500	41.1	0.0
	1100	41.1	39.0
	1730	40.2	34.8
	2330	39.8	0.0
03/31/98			
	0530	40.9	40.9
	1130	40.9	37.3
	1730	38.0	0.0
	2330	37.2	38.0
04/01/98			
	0530	35.7	0.0
	1130	35.0	48.7
	1730	36.1	0.0
	2330	41.5	0.0
04/02/98			
	0530	46.7	0.0
	1130	48.6	5.1
	1730	48.2	0.0
	2330	47.6	19.7
04/03/98			
	0530	46.0	0.0
	1130	44.5	29.6
	1730	44.1	0.0
	2330	42.6	0.0
04/04/98			
	0530	41.1	30.0
	1130	40.4	0.0
	1730	41.1	88.7
	2330	40.4	54.2
04/05/98			
	0630	39.3	52.3
	1230	39.8	54.9
	1830	38.9	47.4
04/06/98			
	0030	37.6	59.9
	0630	37.2	46.0
	1230	36.1	64.0
	1830	34.2	64.2

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
5	03/03/98	17.1	28.1	03/07/98	03/18/98	115137

Comments: Saw Dust to Centra dry 3 to 1 ratio for a total of 13.2 tons

Date	Time	Temperature in C.	CFM'S
04/06/98			
04/07/98			
	0030	33.7	0.0
	0630	34.2	72.2
	1330	34.8	47.1
	1930	34.4	39.3
04/08/98			
	0130	33.5	47.1
	0730	33.9	48.7
	1330	33.1	27.3
	1930	32.6	30.5
04/09/98			
	0130	33.1	50.0
	0730	32.4	38.7
	1330	31.6	36.6
	1930	30.9	37.0
04/10/98			
	0130	30.9	55.2
	0730	30.0	15.2
	1330	29.6	29.2
	1930	30.0	40.6
04/11/98			
	0130	29.4	52.0
	0730	29.2	18.3
	1330	29.4	17.6
	1930	29.4	26.4
04/12/98			
	0130	28.5	0.0
	0730	28.3	44.8
	1330	29.2	45.4
	1930	28.3	35.2
04/13/98			
	0130	28.3	44.3
	0730	28.5	45.1
04/14/98			
	1630	30.0	44.3
	2230	30.0	42.8
04/15/98			
	0430	30.5	53.7
	0700	30.0	29.6
	0900	29.8	38.7
	1100	30.5	52.0
	1400	30.7	270.0
	2000	31.1	88.2

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
5	03/03/98	17.1	28.1	03/07/98	03/18/98	115137

Comments: Saw Dust to Centra dry 3 to 1 ratio for a total of 13.2 tons

Date	Time		Temperature in C.	CFM'S
04/15/98				
04/16/98				
	0200		31.6	54.2
	0800		32.2	48.4
	1400		33.1	67.4
	2000		33.5	276.0
04/17/98				
	0200		33.5	65.4
	0800		33.9	75.8
	1400		34.2	87.3
	2000		34.4	81.1
04/18/98				
	0200		34.4	278.0
	0800		35.0	136.0
	1400		35.9	76.3
	2000		36.1	96.2
04/19/98				
	0200		35.7	143.0
	0800		35.9	78.8
	1400	0.0		0.0
	2000	0.0		0.0
04/20/98				
	0200	0.0		0.0

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
6	03/03/98	10.3	16.6	03/12/98	03/22/98	83602

Comments: Saw Dust to Denatured Cake 3 to 1 ratio for a total of 16.2 tons

Date	Time	Temperature in C.	CFM'S
03/03/98			
	1900	13.6	31.7
03/04/98			
	0100	14.1	23.8
	0700	12.1	194.0
	1300	15.6	64.8
	1900	22.9	46.0
03/05/98			
	0100	40.2	12.4
	0700	51.0	46.3
	1300	57.3	39.7
	1900	56.4	25.4
03/06/98			
	0100	49.9	0.0
	0700	47.6	0.0
	1300	43.9	52.8
	1900	46.5	36.6
03/07/98			
	0100	42.6	107.0
	0700	40.9	13.4
	1300	37.4	51.0
	1900	33.5	38.0
03/08/98			
	0100	36.5	39.7
	0700	51.0	32.5
	1300	56.2	40.3
	1900	59.9	33.3
03/09/98			
	0100	57.9	34.8
	0700	54.9	33.3
	1300	56.8	37.3
	1900	57.3	37.3
03/10/98			
	0100	57.1	36.6
	0700	55.1	31.7
	1300	53.0	24.9
	1900	47.6	0.0
03/11/98			
	0100	49.9	57.9
	0700	51.0	7.2
	1300	68.9	129.0
	1900	45.6	122.0
03/12/98			
	0100	55.3	5.1

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
6	03/03/98	10.3	16.6	03/12/98	03/22/98	83602

Comments: Saw Dust to Denatured Cake 3 to 1 ratio for a total of 16.2 tons

Date	Time	Temperature in C.	CFM'S
03/12/98			
	0700	65.3	67.9
	1300	67.0	159.0
	1900	61.0	165.0
03/13/98			
	0100	60.5	87.3
	0700	60.1	54.4
	1300	60.1	46.3
	1900	59.4	109.0
03/14/98			
	0100	60.5	93.6
	0700	60.1	12.4
	1300	59.9	151.0
	1900	59.9	110.0
03/15/98			
	0100	60.5	72.9
	0700	60.1	183.0
	1300	60.1	111.0
	1900	59.9	62.2
03/16/98			
	0100	59.9	77.3
	0700	59.9	90.0
	1300	60.1	89.2
	1900	59.9	81.5
03/17/98			
	0100	59.9	191.0
	0700	56.2	16.1
	1300	50.1	42.8
	1900	54.9	39.7
03/18/98			
	0100	59.7	29.6
	0700	57.9	23.3
	1300	46.3	49.5
	1900	30.9	27.3
03/19/98			
	0100	29.4	0.0
	0700	36.7	28.3
	1300	32.6	46.5
	1900	30.9	0.0
03/20/98			
	0100	32.9	0.0
	0700	34.2	0.0
	1300	70.7	231.0
	1900	34.6	20.9

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
6	03/03/98	10.3	16.6	03/12/98	03/22/98	83602

Comments: Saw Dust to Denatured Cake 3 to 1 ratio for a total of 16.2 tons

Date	Time	Temperature in C.	CFM'S
03/20/98			
03/21/98			
	0100	44.7	17.6
	0700	54.9	19.0
	1300	59.4	26.4
	1900	59.0	25.9
03/22/98			
	0100	59.4	25.4
	0700	59.0	19.7
	1300	58.8	36.6
	1900	59.0	19.0
03/23/98			
	0100	57.5	16.1
	0700	54.9	15.2
	1300	51.4	21.5
	1900	49.3	8.8
03/24/98			
	0100	46.3	47.4
	0700	41.9	24.3
	1300	41.1	37.0
	1900	39.6	40.0
03/25/98			
	0100	38.0	26.4
	0700	36.1	21.5
	1300	34.6	34.8
	1900	33.5	25.9
03/26/98			
	0100	31.1	12.4
	0700	29.2	15.2
	1300	29.4	0.0
	1900	29.4	0.0
03/27/98			
	0100	29.6	0.0
	0700	29.4	0.0
	1300	29.4	34.1
	1900	29.0	11.4
03/28/98			
	0100	28.5	19.7
	0700	28.3	0.0
	1300	28.5	40.0
	1900	27.9	18.3
03/29/98			
	0100	27.5	0.0
	0700	27.2	0.0

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
6	03/03/98	10.3	16.6	03/12/98	03/22/98	83602

Comments: Saw Dust to Denatured Cake 3 to 1 ratio for a total of 16.2 tons

Date	Time	Temperature in C.	CFM'S
03/29/98			
	1300	27.7	196.0
	1900	27.0	27.8
03/30/98			
	0100	26.2	0.0
	0700	26.2	7.2
	1300	26.2	16.8
	1930	24.2	14.4
03/31/98			
	0130	22.3	14.4
	0730	20.8	21.5
	1330	20.1	30.0
	1930	19.7	25.4
04/01/98			
	0130	19.0	0.0
	0730	17.9	0.0
	1330	17.7	35.5
	1930	16.9	23.8
04/02/98			
	0130	15.1	0.0
	0730	13.8	230.0
	1330	13.8	16.1
	1930	12.5	0.0
04/03/98			
	0130	11.5	0.0
	0730	10.4	0.0
	1330	9.7	37.7
	1930	8.9	46.3
04/04/98			
	0130	8.2	0.0
	0730	7.6	0.0
	1330	7.3	0.0
	1930	7.1	49.5
04/05/98			
	0130	6.9	13.4
	0830	6.9	0.0
	1430	7.1	186.0
	2030	6.9	0.0
04/06/98			
	0230	6.5	0.0
	0830	6.9	32.1
	1430	7.1	43.7
	2030	7.1	57.4
04/07/98			

Started to lose temp, could not raise it again, even after re-mixing.

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
6	03/03/98	10.3	16.6	03/12/98	03/22/98	83602

Comments: Saw Dust to Denatured Cake 3 to 1 ratio for a total of 16.2 tons

Date	Time	Temperature in C.	CFM'S
04/07/98			
	0230	7.1	0.0
	0930	7.1	11.4
	1530	7.3	34.8
	2130	7.1	0.0
04/08/98			
	0330	6.9	30.0
	0930	6.9	46.0
	1530	7.3	35.5
	2130	7.1	45.1
04/09/98			
	0330	7.1	34.1
	0930	7.1	41.2
	1530	7.3	0.0
	2130	6.9	20.9
04/10/98			
	0330	6.5	42.5
	0930	6.3	0.0
	1530	6.5	32.1
	2130	6.9	40.6
04/11/98			
	0330	6.5	33.7
	0930	6.5	0.0
	1530	6.9	24.9
	2130	6.9	0.0
04/12/98			
	0330	6.5	0.0
	0930	6.9	42.8
	1530	7.3	34.8
	2130	6.9	0.0
04/13/98			
	0330	6.9	0.0
04/14/98	1230	0.0	0.0
	1830	7.3	29.6
04/15/98			
	0030	7.1	11.4
	0530	0.0	0.0
	0730	0.0	0.0
	0930	0.0	0.0
	1130	0.0	0.0
	1600	12.3	31.3
	2200	13.0	50.8
04/16/98			
	0400	13.0	0.0

LRI Compost Reports 04/20/98

BIN NUMBER	DATE STARTED	DAYS OVER 55 C.	DAYS OVER 40 C.	DATE PFRP WAS MET	DATE VEC. WAS MET	TOTAL CFMS'
6	03/03/98	10.3	16.6	03/12/98	03/22/98	83602

Comments: Saw Dust to Denatured Cake 3 to 1 ratio for a total of 16.2 tons

Date	Time	Temperature in C.	CFM'S
04/16/98			
	1000	12.8	0.0
	1600	12.8	0.0
	2200	12.8	199.0
04/17/98			
	0400	12.5	0.0
	1000	12.8	25.4
	1600	12.8	29.6
	2200	12.5	0.0
04/18/98			
	0400	12.3	0.0
	1000	12.5	0.0
	1600	12.8	45.4
	2200	12.3	0.0
04/19/98			
	0400	12.3	0.0
	1000	12.5	0.0
	1600	0.0	0.0
	2200	0.0	0.0
04/20/98			
	0400	0.0	0.0

King County Department of Natural Resources
Wastewater Treatment Division
Applied Wastewater Technologies Program

Exchange Building, MS 107 • 821 Second Ave. • Seattle, WA 98104-1598

November 3, 1998

To: Distribution

From: Bob Bucher
AWT Program – Centridry Project

Subject: LRI composting trial data

Find enclosed a copy of the Land Recovery Inc. (LRI) Centridry product composting data. **Please review and forward any comments.** The data will eventually be summarized and included in a final King County project report.

RECEIVED
NOV 0 9 1998
BROWN & C...
SEATTLE

Distribution:
Jeff Gage, LRI
Sue Hennig, KC BMP
Gary Newman, Brown and Caldwell
Larry Sasser, E & A Environmental Consultants

LRI composting of Centridry product
Data Summary

Cdry only mix / no bulking mat'l Date	pH	Total Solids (%)	Total Volatile Solids (%)	NH_4-N (mg/kg dry)	TKN (mg/kg dry)	Org-N (mg/kg dry)	NO_3-N (mg/kg dry)	TP (mg/kg dry)	Potassium (mg/kg dry)	Lab Bulk Density (g/ml)	(lbs/cy)	Field Bulk Density (lbs/5 gal)	(lbs/cy)	Micro Results Salmonellae (MPN/100g dry)	Fecal Coliform (MPN/100g dry)
17-Jul	7.92	50.9	33.4	18,900	55,000	36,100		30,300	2,400	0.648	1,090				
3-Aug	7.56	54.9	34.6							0.716	1,204			<5 (MDL)	36
17-Aug	7.88	51.4	27.9							0.895	1,505				
31-Aug	8.17	70.7	43.2	13,700	46,700	33,000	<28 (MDL)	34,700	2,480	0.678	1,140			<3 (MDL)	<3 (MDL)

King County Environmental Lab Analytical Report

PROJECT: 423163-49

Locator: LRIPILE5
Descrip: Off-site LRI compo
Client Loc: Centridry product - no bulking agent
Sampled: Aug 31, 98
Lab ID: L14115-1
Matrix: COMPOST
% Solids: 70.7

Parameters	Value	Qual	MDL	RDL	Units
			- Dry Weight Basis		
COMBINED LABS					
M.Code=Conventionals EPA 300					
Nitrate Nitrogen		<MDL	28		mg/Kg
M.Code=Conventionals EPA 351-2					
Total Kjeldahl Nitrogen	46700		71		mg/Kg
M.Code=Conventionals SM2540 B,M					
Bulk Density	0.678		0.000014	0.0000283	g/ml
M.Code=Conventionals SM2540-G					
Total Solids *	70.7		0.005	0.01	%
Total Volatile Solids *	43.2		0.005	0.01	%
M.Code=Conventionals SM4500 B D					
Ammonia Nitrogen	13700		1.4		mg/Kg
M.Code=Conventionals SM4500-P-B,F Modified					
Total Phosphorus	34700		890	1770	mg/Kg
M.Code=Conventionals SW846 9045					
pH *	8.17				pH
M.Code=Metals METRO 16-01-005					
Mercury, Total, CVAA	3.08		0.11	1.06	mg/Kg
M.Code=Metals METRO 16-02-004					
Cadmium, Total, ICP	7.93		0.21	1.05	mg/Kg
Chromium, Total, ICP	49.4		0.35	1.75	mg/Kg
Copper, Total, ICP	786		0.28	1.4	mg/Kg
Lead, Total, ICP	61.2		2.1	10.5	mg/Kg
Nickel, Total, ICP	25.5		1.4	7.02	mg/Kg
Potassium, Total, ICP	2480		140	702	mg/Kg
Zinc, Total, ICP	663		0.35	1.75	mg/Kg
M.Code=Metals METRO 16-04-001					
Arsenic, Total, ICP-MS	8.51		0.18	0.707	mg/Kg
Molybdenum, Total, ICP-MS	15.6		0.18	0.707	mg/Kg
Selenium, Total, ICP-MS	7.06		0.35	1.77	mg/Kg
M.Code=Micros METRO MC MM Sec.7					
Salmonellae		<MDL	3		MPN/100g
M.Code=Micros METRO MC SOP 6.1.3					
Fecal Coliform		<MDL	3		MPN/100g

* Not converted to dry weight basis for this parameter

ANALYTICAL CHEMISTS
and
BACTERIOLOGISTS
Approved by State of California

SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE

Tel: 408 724-5422
FAX: 408 724-3188

King County WPCD Env. Lab
Subcontract Analysis Coordinator
322 W. Ewing Str. MS-LAB
Seattle WA 98119
Attn Richelle rose

130263-1-3940

COMPOST ANALYSIS Chemical

Date Received: 01 September 1998
Sample Identification: Compost L14115-1
Sample Id. Number: 1/1-130263

Constituents:	Received %	Dry %
Tot. Nitrogen (TN)	3.4	5.8
Organic N (Org-N)	2.9	4.9
Ammonia (NH3-N)	0.50	0.86
Nitrate (NO3-N)	0.0054	0.009
Phosphorus (P2O5)	3.7	6.3
Potassium (K2O)	0.23	0.39
Calcium (Ca)	1.7	3.0
Magnesium (Mg)	0.38	0.66
Sulfate (SO4-S)	0.14	0.24
Chloride (Cl)	0.033	0.057
Sodium (Na)	0.076	0.13
Moisture	41.9	0.0
Organic Matter	34.7	59.8
Ash	23.3	40.2
Bulk Den. lb/cuft	42.5	24.7
pH value (units)	8.3	X
EC(EC5w/w)mmhos/c	7.6	X

Interpretation: (for finished compost)	Dry Wt: Value	Quality Rating
Nutrients (N+P2O5+K2O)	13	A
Organic:Ash	1.5	A
C:N Ratio ((OM/2)/N)	5	A
pH Value	8.3	C
AgIndex ((Nutrients)/(Na+Cl))	>10	A
Total Dissolved Salts (% w/w) (EC X 640 = mg/L TDS)	2.4	A
Calcium:Magnesium Ratio	4	A
Carbonate (as CaCO3)(lb/Ton)	6	B

A=Good; B= Average; C= Caution

Application Rates may be limited by the following:

Nutrients for Crop requirement
pH of soil and/or toxins if un-cured compost

Soil may require additional Magnesium

ANALYTICAL CHEMISTS
and
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SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE

Tel: 408 724-5422
FAX: 408 724-3188

130263-1-3940

King County WPCD Env. Lab
Subcontract Analytical coordinator
322 W. Ewing Str. MS-LAB
Seattle WA 98119
Attn: Richelle rose

Cation Exchange Capacity

Date Received:	01 September 1998
Sample Identification:	Compost L14115-1
Sample Id. Number:	1/1-130263

Cation Exchange Capacity (C.E.C.)

122 meq/100 g dw

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SOIL CONTROL LAB

42 HANGAR WAY
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CALIFORNIA

Tel: 408 724-5422
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King County WPCD Env. Lab
Subcontract Analytical Coordinator
322 W. Ewing Str. MS-LAB
Seattle WA 98119
Attn: Richelle rose

130263-1-3940

RESPIRATION RATE

Date Sample Received:	01 September 1998
Lab Number:	1/1-130263
Identification:	Compost L14115-1

SAMPLE REMOVED (% dry wt.)		TEST CONDITIONS	
Non-Compostable (> 4mm)	< 0.1	Temperature(deg C)	37
SAMPLE USED (% dry wt.)		Moisture Adj.	62% OM + 20% Ash
Total Solids	100.0	Add: Nutrients	Yes
Inorganic Matter	40.2	pH Adj.	Yes
Biodegradable Vol. Solids	59.8	Microbes	Yes

CO2 Production	Org. Fraction	CO2 Production	Total Solids
CO_2 (mg/Kg-bvs/Hr)	1211	CO_2 (mg/KgHr)	724
CO_2 (ml/Kg-bvs/Hr)	616	CO_2 (ml/KgHr)	369
Carbon Depleted		Carbon Depleted	
C (mg/Kg-bvs/Hr)	330	C (mg/KgHr)	197
C (% C/day)	1.4		
Oxygen Consumed (from CO2 produced)		Oxygen Consumed (from CO2 produced)	
O_2 (mg/Kg-bvs/Hr)	880	O_2 (mg/KgHr)	526
O_2 (ml/Kg-bvs/Hr)	616	O_2 (ml/KgHr)	369

Rating: MODERATE UN-STABLE: Moving past active phase; uncured; soil applied may result in N immobilization/toxicity; use with caution.

USES: NOTE: Based on this test alone. Mulch and green manures

bvs = Biodegradable Volatile Solids

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SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE

Tel: 408 724-5422
FAX: 408 724-3188

130263-1-3940

King County WPCD Env. Lab
Subcontract Analytical Coordinator
322 W. Ewing Street, MS-LAB
Seattle WA 98119
Attn: Richelle rose

Seed Germination and Root Elongation Bioassy

Date Received:	01 September 1998
Sample Identification:	Compost L14115-1
Sample Id. Number:	1/1-130263

COMPOST		TEST		CONTROL	
pH value:	8.3	Seed:	Cress	Mean Control Germination	
Moisture %:	41.9	Temperature:	25	MCG =	100.0
Organic Matter %:	34.7	Incubation(Hours):	48	Mean Control Radicle Length	
Ash %	23.3	Dil. (water/Sdry):	2.0	MCRL =	9.2

Data:	Mean Treat. Germination	Mean Treatment Radicle Length	Germination Index (GI)
Un-diluted			
Avg. 5 Reps.	0.0	0.0	0.0
3 X Dil.			
Avg. 5 Reps.	0.0	0.0	0.0
10 X Dil.			
Avg. 5 Reps.	94.0	8.7	0.9
		Avg. GI	0.3

Interpretation:

GI	Rating	Characterstic
1.0-0.8	Very Mature	No phytotoxicity/No odor
0.8-0.6	Mature	Min.phytotoxicity/No odor
0.6-0.4	Immature	Phytotoxicity/Characteristic Odor
Less than 0.4	Very immature	Phytotoxicity/Strong Odor

King County Department of Natural Resources
Wastewater Treatment Division
Applied Wastewater Technologies Program
Exchange Building, MS 95 • 821 Second Ave. • Seattle, WA 98104-1598

November 3, 1998

To: Distribution

From: Bob Bucher
AWT Program – Centridry Project

Subject: GroCo composting trials data

Find enclosed a copy of the GroCo (Centridry product) composting data. **Please review and forward any comments**. The data will eventually be summarized and included in a final King County project report.

Distribution:
Curley Winebrenner, Sawdust Supply
Sue Hennig, KC BMP
Gary Newman, Brown and Caldwell
Larry Sasser, E & A Environmental Consultants

GroCo Composting of Centridry product

2:1 mix sawdust:Cdry		Total	Total								Lab Bulk		Field Bulk		Micro Results	
		Solids	Volatile Solids	NH_4-N	TKN	**Org-N**	NO_3-N	TP	Potassium	Ave Temp	Density		Density		Salmonellae	Fecal Coliform
Date	pH	(%)	(%)	(mg/kg dry)	(mg/kg dry)	**(mg/kg dry)**	(mg/kg)	(mg/kg dry)	(mg/kg dry)	(°C)	(g/ml)	(lbs/cy)	(lbs/5 gal)	(lbs/cy)	(MPN/100g)	(MPN/100g)
9-Mar	7.10	48.9	35.6	458	32,700	**32,242**		3,760	1,440		0.538	905	25	1,010	<MDL	1.00E+08
6-Apr	7.91	40.9	29.8								1.17	1,968				
4-May	8.50	54.1	36.3							55	0.503	846	16	646		
15-Jun	7.63	43.9	30.6	9,040	25,100	**16,060**				62	0.829	1,394	24	970		
6-Jul	7.00	46.6	32.1							34	0.7	1,177	18.5	747		
4-Aug	6.66	49.2	31.8								0.646	1,086				
21-Sep	7.14	53.6	38.7	4,290	24,440	**20,150**	1,100	20,500	1,360	39	0.565	950	16.5	667	<MDL	2400

3:1 mix sawdust:Cdry		Total	Total								Lab Bulk		Field Bulk		Micro Results	
		Solids	Volatile Solids	NH_4-N	TKN	**Org-N**	NO_3-N	TP	Potassium	Ave Temp	Density		Density		Salmonellae	Fecal Coliform
Date	pH	(mg/L)	(mg/L)	(mg/kg dry)	(mg/kg dry)	**(mg/kg dry)**	(mg/kg)	(mg/kg dry)	(mg/kg dry)	(°C)	(g/ml)	(lbs/cy)	(lbs/5 gal)	(lbs/cy)	(MPN/100g)	(MPN/100g)
9-Mar	6.83	41.7	33.4	571	18,000	**17,429**		8,270	1100 *		0.719	1,209	23	929	4.8	1.90E+07
6-Apr	7.34	43.1	34.1								1.3	2,186				
4-May	8.52	49.6	39.8							56	0.597	1,004	18	727		
15-Jun	7.22	41.7	32.2	5,280	15,300	**10,020**				57	0.811	1,364	22	889		
6-Jul	6.69	37.4	28.9							33	0.856	1,440	19.5	788		
4-Aug	6.59	45.1	32.9								0.718	1,208				
21-Sep	6.62	49.3	36.7	6,490	20,690	**14,200**	1,660	17,700	1270	36	0.643	1,081	16	646	<MDL	6100

4:1 mix sawdust:Cdry		Total	Total								Lab Bulk		Field Bulk		Micro Results	
		Solids	Volatile Solids	NH_4-N	TKN	**Org-N**	NO_3-N	TP	Potassium	Ave Temp	Density		Density		Salmonellae	Fecal Coliform
Date	pH	(mg/L)	(mg/L)	(mg/kg dry)	(mg/kg dry)	**(mg/kg dry)**	(mg/kg)	(mg/kg dry)	(mg/kg dry)	(°C)	(g/ml)	(lbs/cy)	(lbs/5 gal)	(lbs/cy)	(MPN/100g)	(MPN/100g)
9-Mar	7.28	38.3	29.5	462	24,500	**24,038**		5,330	1300 *		0.937	1,576	25	1,010	<MDL	2.10E+07
6-Apr	7.24	35.0	27.9								1.15	1,934				
4-May	8.69	44.3	34.5							56.5	0.684	1,150	19	768		
15-Jun	7.24	37.4	29.4	5,780	18,200	**12,420**				61	0.984	1,655	20	808		
6-Jul	6.66	35.4	27.7							41	1.08	1,816	20.5	828		
4-Aug	6.52	42.2	31.5								0.794	1,335				
21-Sep	6.73	46.5	36.0	5,810	19,312	**13,502**	667	15,600	1,240	38.9	0.738	1,241	18	727	<MDL	1700

Sawdust Bulking Material		Total	Total						Micro Results	
		Solids	Volatile Solids	NH_4-N	TKN	NO_3-N	TP	TP	Salmonellae	Fecal Coliform
Date	pH	(mg/L)	(mg/L)	(mg/kg dry)	(mg/kg dry)	(mg/kg)	(mg/kg dry)	(mg/kg dry)	(MPN/100g)	(MPN/100g)
9-Mar		38.8							<MDL	7.70E+02

* = less than RDL

King County Environmental Lab Analytical Report

PROJECT: 423163-49

	SSMIX1	SSMIX2	SSMIX3
Locator:	SSMIX1	SSMIX2	SSMIX3
Descrip:	Off-site Sawdust S	Off-site Sawdust S	Off-site Sawdust S
Client Loc:	2:1 Sawdust:Centridry	3:1 Sawdust:Centridry	4:1 Sawdust:Centridry
Sampled:	Sep 21, 1998	Sep 21, 1998	Sep 21, 1998
Lab ID:	L14230-1	L14230-2	L14230-3
Matrix:	COMPOST	COMPOST	COMPOST
% Solids:	53.6	49.3	46.5

Parameters	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			- Dry Weight Basis					- Dry Weight Basis					- Dry Weight Basis		
COMBINED LABS															
M.Code=Conventionals EPA 351.2															
Total Kjeldahl Nitrogen	24300		93		mg/Kg	20300		100		mg/Kg	19400		110		mg/Kg
M.Code=Conventionals SM2540 B,M															
Bulk Density	0.565		0.000019	0.0000373	g/ml	0.643		0.00002	0.0000406	g/ml	0.738		0.000022	0.000043	g/ml
M.Code=Conventionals SM2540-G															
Total Solids *	53.6		0.005	0.01	%	49.3		0.005	0.01	%	46.5		0.005	0.01	%
Total Volatile Solids *	38.7		0.005	0.01	%	36.7		0.005	0.01	%	36		0.005	0.01	%
M.Code=Conventionals SM4500-NH3-H															
Ammonia Nitrogen	4290		0.19		mg/Kg	6490		0.2		mg/Kg	5810		0.22		mg/Kg
M.Code=Conventionals SM4500-NO3-F															
Nitrate Nitrogen	1100		3.7		mg/Kg	1660		4.1		mg/Kg	667		4.3		mg/Kg
M.Code=Conventionals SM4500-P-B,F Modified															
Total Phosphorus	20500		240	466	mg/Kg	17700		260	507	mg/Kg	15600		280	538	mg/Kg
M.Code=Conventionals SW846 9045															
pH *	7.14				pH	6.62				pH	6.73				pH
M.Code=Metals METRO 16-01-005															
Mercury, Total, CVAA	1.87		0.14	1.38	mg/Kg	1.57		0.15	1.53	mg/Kg	1.7	<RDL	0.17	1.71	mg/Kg
M.Code=Metals METRO 16-02-004															
Cadmium, Total, ICP	5.02		0.28	1.37	mg/Kg	4.67		0.3	1.5	mg/Kg	3.87		0.32	1.61	mg/Kg
Chromium, Total, ICP	34.3		0.45	2.28	mg/Kg	31.2		0.51	2.49	mg/Kg	28.4		0.54	2.69	mg/Kg
Copper, Total, ICP	521		0.37	1.82	mg/Kg	462		0.41	2	mg/Kg	385		0.43	2.14	mg/Kg
Lead, Total, ICP	49.1		2.8	13.7	mg/Kg	43		3	15	mg/Kg	47.1		3.2	16.1	mg/Kg
Nickel, Total, ICP	23.5		1.8	9.12	mg/Kg	21.7		2	10	mg/Kg	19.8		2.2	10.7	mg/Kg
Potassium, Total, ICP	1360		180	912	mg/Kg	1270		200	1000	mg/Kg	1240		220	1070	mg/Kg
Zinc, Total, ICP	450		0.45	2.28	mg/Kg	398		0.51	2.49	mg/Kg	363		0.54	2.69	mg/Kg
M.Code=Metals METRO 16-04-001															
Arsenic, Total, ICP-MS	5.58		0.22	0.931	mg/Kg	5.5		0.26	1.01	mg/Kg	4.56		0.26	1.06	mg/Kg
Molybdenum, Total, ICP-MS	9.38		0.22	0.931	mg/Kg	9.05		0.26	1.01	mg/Kg	6.77		0.26	1.06	mg/Kg
Selenium, Total, ICP-MS	4.65		0.47	2.33	mg/Kg	4.38		0.51	2.54	mg/Kg	3.55		0.54	2.67	mg/Kg
M.Code=Micros METRO MC MM Sec.7															
Salmonellae		<MDL	4		MPN/100g		<MDL	4		MPN/100g		<MDL	4		MPN/100g
M.Code=Micros METRO MC SOP 6.1.3															
Fecal Coliform	2400				MPN/100g	6100				MPN/100g	1700				MPN/100g

* Not converted to dry weight basis for this parameter

ANALYTICAL CHEMISTS
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SOIL CONTROL LAB

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FAX: 408 724-3188

130771-3-3940

King County WPCD Environmental Laboratory
322 W. Ewing St. MS-LAB
Seattle WA 98119
Attn Richelle rose

COMPOST ANALYSIS Chemical

Date Received: 22 September 1998
Sample Identification: Sample # P14230-1 (SSMix1-Groco-Mix1)
Sample Id. Number: 1/3-130771

Constituents:	Receive %	Dry %	Interpretation: (for finished compost)	Dry Wt: Value	Quality Rating
Tot. Nitrogen (TN)	1.7	2.8	Nutrients (N+P2O5+K2O)	6	A
Organic N (Org-N)	1.3	2.1	Organic:Ash	2.4	A
Ammonia (NH3-N)	0.33	0.55	C:N Ratio ((OM/2)/N)	13	A
Nitrate (NO3-N)	0.058	0.097	pH Value	6.8	A
Phosphorus (P2O5)	1.5	2.5	AgIndex ((Nutrients)/(Na+Cl))	>10	A
Potassium (K2O)	0.17	0.3	Total Dissolved Salts (% w/w)	1.9	A
Calcium (Ca)	1.4	2.3	(EC X 640 = mg/L TDS)		
Magnesium (Mg)	0.25	0.42	Calcium:Magnesium Ratio	6	B
Sulfate (SO4-S)	0.18	0.30	Carbonate (as CaCO3)(lb/Ton)	10	A
Chloride (Cl)	0.02	0.04	A=Good; B= Average; C= Caution		
Sodium (Na)	0.07	0.11	Application Rates may be limited by the following:		
Moisture	40.2	0.0			
Organic Matter	42.3	70.8	Nutrients for Crop requirement		
Ash	17.4	29.2			
Bulk Den. lb/cuft	28.6	17.1			
pH value (units)	6.8	X			
EC(EC5w/w)mmhos/c	5.8	X			

Cation Exchange Capacity
187 meq/100 g

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Attn Richelle rose

130771-3-3940

RESPIRATION RATE

Date Sample Received: 22 September 1998
Lab Number: 1/3-130771
Identification: Sample # P14230-1 (SSMix1-Groco-Mix1)

SAMPLE REMOVED (% dry wt.)		TEST CONDITIONS	
Non-Compostable (> 4mm)	< 0.1	Temperature(deg C)	37
SAMPLE USED (% dry wt.)		Moisture Adj.	62% OM + 20% Ash
Total Solids	100.0	Add: Nutrients	Yes
Inorganic Matter	29.2	pH Adj.	Yes
Biodegradable Vol. Solids	70.8	Microbes	Yes

CO2 Production	Org. Fraction	CO2 Production	Total Solids
CO_2 (mg/Kg-bvs/Hr)	266	CO_2 (mg/KgHr)	188
CO_2 (ml/Kg-bvs/Hr)	135	CO_2 (ml/KgHr)	96
Carbon Depleted		Carbon Depleted	
C (mg/Kg-bvs/Hr)	72	C (mg/KgHr)	51
C (% C/day)	0.3		
Oxygen Consumed (from CO2 produced)		Oxygen Consumed (from CO2 produced)	
O_2 (mg/Kg-bvs/Hr)	193	O_2 (mg/KgHr)	137
O_2 (ml/Kg-bvs/Hr)	135	O_2 (ml/KgHr)	96

Rating: VERY STABLE:
Mature compost; well aged; possibly over-aged like soil; Ready for most uses.
0

USES: NOTE: Based on this test alone.
Growing medium with/without additional blending
Formulating growing medium for potted crops
Top dressing turf. Landscape planting.

bvs = Biodegradable Volatile Solids

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130771-3-3940

Seed Germination and Root Elongation Bioassy

Date Received: 22 September 1998
Sample Identification: Sample # P14230-1 (SSMix1-Groco-Mix1)
Sample Id. Number: 1/3-130771

COMPOST		TEST		CONTROL	
pH value:	6.8	Seed:	Cress	Mean Control Germination	
Moisture %:	40.2	Temperature:	25	MCG =	98.0
Organic Matter %:	42.3	Incubation(Hours):	48	Mean Control Radicle Length	
Ash %	17.4	Dilution (X Sat.):	2.0	MCRL =	6.0

Data:	Mean Treat. Germination	Mean Treatment Radicle Length		Germination Index (GI)
Un-diluted Avg. 5 Reps.	82.0	4.8		0.7
3 X Dil. Avg. 5 Reps.	98.0	12.8	Greater than	1.0
10 X Dil. Avg. 5 Reps.	100.0	14.9	Greater than	1.0
			Avg. GI	0.9

Interpretation:

GI	Rating	Characterstic
1.0-0.8	Very Mature	No phytotoxicity/No odor
0.8-0.6	Mature	Min.phytotoxicity/No odor
0.6-0.4	Immature	Phytotoxicity/Characteristic Odor
Less than 0.4	Very immature	Phytotoxicity/Strong Odor

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COMPOST ANALYSIS Chemical

Date Received:	22 September 1998
Sample Identification:	Sample # P14230-2 (SSMix2-Groco-Mix2)
Sample Id. Number:	2/3-130771

Constituents:	Receive %	Dry %	Interpretation: (for finished compost)	Dry Wt: Value	Quality Rating
Tot. Nitrogen (TN)	1.4	2.8	Nutrients (N+P2O5+K2O)	6	A
Organic N (Org-N)	1.0	2.0	Organic:Ash	3.5	A
Ammonia (NH3-N)	0.28	0.55	C:N Ratio ((OM/2)/N)	14	B
Nitrate (NO3-N)	0.097	0.19	pH Value	6.5	B
Phosphorus (P2O5)	1.6	3.3	AgIndex ((Nutrients)/(Na+Cl))	>10	A
Potassium (K2O)	0.13	0.25	Total Dissolved Salts (% w/w)	1.8	A
Calcium (Ca)	1.0	2.1	(EC X 640 = mg/L TDS)		
Magnesium (Mg)	0.18	0.36	Calcium:Magnesium Ratio	6	B
Sulfate (SO4-S)	0.15	0.30	Carbonate (as CaCO3)(lb/Ton)	3	A
Chloride (Cl)	0.021	0.041	A=Good; B= Average; C= Caution		
Sodium (Na)	0.070	0.14	Application Rates may be limited by the following:		
Moisture	50.2	0.0			
Organic Matter	38.6	77.5	Nutrients for Crop requirement		
Ash	11.2	22.5	Toxins if un-cured compost		
Bulk Den. lb/cuft	31.2	15.5	Soil may require additional Nitrogen		
pH value (units)	6.5	X			
EC(EC5w/w)mmhos/c	5.7	X			

Cation Exchange Capacity
189 meq/100 g

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130771-3-3940

RESPIRATION RATE

Date Sample Received: 22 September 1998
Lab Number: 2/3-130771
Identification: Sample # P14230-2 (SSMix2-Groco-Mix2)

SAMPLE REMOVED (% dry wt.)		TEST CONDITIONS	
Non-Compostable (> 4mm)	< 0.1	Temperature(deg C)	37
SAMPLE USED (% dry wt.)		Moisture Adj.	62% OM + 20% Ash
Total Solids	100.0	Add: Nutrients	Yes
Inorganic Matter	22.5	pH Adj.	Yes
Biodegradable Vol. Solids	77.5	Microbes	Yes

CO2 Production	Org. Fraction	CO2 Production	Total Solids
CO2 (mg/Kg-bvs/Hr)	228	CO2 (mg/KgHr)	177
CO2 (ml/Kg-bvs/Hr)	116	CO2 (ml/KgHr)	90
Carbon Depleted		Carbon Depleted	
C (mg/Kg-bvs/Hr)	62	C (mg/KgHr)	48
C (% C/day)	0.3		
Oxygen Consumed (from CO2 produced)		Oxygen Consumed (from CO2 produced)	
O2 (mg/Kg-bvs/Hr)	166	O2 (mg/KgHr)	129
O2 (ml/Kg-bvs/Hr)	116	O2 (ml/KgHr)	90

Rating: VERY STABLE:
Mature compost; well aged; possibly over-aged like soil; Ready for most uses.
0

USES: NOTE: Based on this test alone.
Growing medium with/without additional blending
Formulating growing medium for potted crops
Top dressing turf. Landscape planting.

bvs = Biodegradable Volatile Solids

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130771-3-3940

Seed Germination and Root Elongation Bioassy

Date Received:	22 September 1998
Sample Identification:	Sample # P14230-2 (SSMix2-Groco-Mix2)
Sample Id. Number:	2/3-130771

COMPOST		TEST		CONTROL	
pH value:	6.5	Seed:	Cress	Mean Control Germination	
Moisture %:	50.2	Temperature:	25	MCG =	98.0
Organic Matter %:	38.6	Incubation(Hours):	48	Mean Control Radicle Length	
Ash %	11.2	Dilution (X Sat.):	2.0	MCRL =	6.0

Data:	Mean Treat. Germination	Mean Treatment Radicle Length		Germination Index (GI)
Un-diluted				
Avg. 5 Reps.	88.0	7.3	Greater than	1.0
3 X Dil.				
Avg. 5 Reps.	96.0	5.8		1.0
10 X Dil.				
Avg. 5 Reps.	100.0	14.5	Greater than	1.0
			Avg. GI	1.0

Interpretation:

GI	Rating	Characterstic
1.0-0.8	Very Mature	No phytotoxicity/No odor
0.8-0.6	Mature	Min.phytotoxicity/No odor
0.6-0.4	Immature	Phytotoxicity/Characteristic Odor
Less than 0.4	Very immature	Phytotoxicity/Strong Odor

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COMPOST ANALYSIS Chemical

Date Received:	22 September 1998
Sample Identification:	Sample # P14230-3 (SSMix3-Groco-Mix3)
Sample Id. Number:	3/3-130771

Constituents:	Receive %	Dry %	Interpretation: (for finished compost)	Dry Wt: Value	Quality Rating
Tot. Nitrogen (TN)	1.1	2.5	Nutrients (N+P2O5+K2O)	5	A
Organic N (Org-N)	0.86	1.9	Organic:Ash	3.9	A
Ammonia (NH3-N)	0.23	0.50	C:N Ratio ((OM/2)/N)	16	B
Nitrate (NO3-N)	0.039	0.084	pH Value	6.5	B
Phosphorus (P2O5)	1.2	2.7	AgIndex ((Nutrients)/(Na+Cl))	>10	A
Potassium (K2O)	0.094	0.20	Total Dissolved Salts (% w/w)	1.4	A
Calcium (Ca)	0.75	1.6	(EC X 640 = mg/L TDS)		
Magnesium (Mg)	0.16	0.35	Calcium:Magnesium Ratio	5	A
Sulfate (SO4-S)	0.12	0.26	Carbonate (as CaCO3)(lb/Ton)	2	A
Chloride (Cl)	0.016	0.034	A=Good; B= Average; C= Caution		
Sodium (Na)	0.058	0.13	Application Rates may be limited by the following:		
Moisture	53.9	0.0			
Organic Matter	36.7	79.5	Nutrients for Crop requirement		
Ash	9.4	20.5	Toxins if un-cured compost		
Bulk Den. lb/cuft	36.4	16.8	Soil may require additional Nitrogen		
pH value (units)	6.5	X			
EC(EC5w/w)mmhos/c	4.5	X			

Cation Exchange Capacity
188 meq/100 g

Frank Shirley

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Attn Richelle rose

130771-3-3940

RESPIRATION RATE

Date Sample Received:	22 September 1998
Lab Number:	3/3-130771
Identification:	Sample # P14230-3 (SSMix3-Groco-Mix3)

SAMPLE REMOVED (% dry wt.)		TEST CONDITIONS	
Non-Compostable (> 4mm)	< 0.1	Temperature(deg C)	37
SAMPLE USED (% dry wt.)		Moisture Adj.	62% OM + 20% Ash
Total Solids	100.0	Add: Nutrients	Yes
Inorganic Matter	20.5	pH Adj.	Yes
Biodegradable Vol. Solids	79.5	Microbes	Yes

CO2 Production	Org. Fraction	CO2 Production	Total Solids
CO2 (mg/Kg-bvs/Hr)	158	CO2 (mg/KgHr)	126
CO2 (ml/Kg-bvs/Hr)	81	CO2 (ml/KgHr)	64
Carbon Depleted		Carbon Depleted	
C (mg/Kg-bvs/Hr)	43	C (mg/KgHr)	34
C (% C/day)	0.2		
Oxygen Consumed (from CO2 produced)		Oxygen Consumed (from CO2 produced)	
O2 (mg/Kg-bvs/Hr)	115	O2 (mg/KgHr)	92
O2 (ml/Kg-bvs/Hr)	81	O2 (ml/KgHr)	64

Rating: VERY STABLE:	USES: NOTE: Based on this test alone.
Mature compost; well aged; possibly over-aged like soil; Ready for most uses.	Growing medium with/without additional blending
0	Formulating growing medium for potted crops
	Top dressing turf. Landscape planting.

bvs = Biodegradable Volatile Solids

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130771-3-3940

Seed Germination and Root Elongation Bioassy

Date Received: 22 September 1998
Sample Identification: Sample # P14230-3 (SSMix3-Groco-Mix3)
Sample Id. Number: 3/3-130771

COMPOST		TEST		CONTROL	
pH value:	6.5	Seed:	Cress	Mean Control Germination	
Moisture %:	53.9	Temperature:	25	MCG =	98.0
Organic Matter %:	36.7	Incubation(Hours):	48	Mean Control Radicle Length	
Ash %	9.4	Dilution (X Sat.):	2.0	MCRL =	6.0

Data:	Mean Treat. Germination	Mean Treatment Radicle Length		Germination Index (GI)
Un-diluted				
Avg. 5 Reps.	90.0	6.1		0.9
3 X Dil.				
Avg. 5 Reps.	96.0	6.5	Greater than	1.0
10 X Dil.				
Avg. 5 Reps.	98.0	11.8	Greater than	1.0
			Avg. GI	1.0

Interpretation:

GI	Rating	Characterstic
1.0-0.8	Very Mature	No phytotoxicity/No odor
0.8-0.6	Mature	Min.phytotoxicity/No odor
0.6-0.4	Immature	Phytotoxicity/Characteristic Odor
Less than 0.4	Very immature	Phytotoxicity/Strong Odor

Frank Shields

APPENDIX C-3

OCTOBER 19, 1998 MEMORANDUM--EXTREME SALMONELLA COUNTS FOUND IN THE CENTRIDRY™ PRODUCTS DELIVERED TO LAND RESOURCES RECOVERY, INC. COMPOSTING FACILITY, JULY 1998

October 19, 1998

To: Centridry Project File

From: Bob Bucher
Sue Hennig

RE: Extreme Salmonella Counts Found in the Centridry Product Delivered to Land Resource Recovery Inc. Composting Facility, July 1998

Purpose

- To document sampling results revealing extremely high Salmonella counts found in Centridry product delivered to Land Resource Recovery (LRI) composting facility in July 1998.
- To provide basis for expanding scope of the proposed extension of the Centridry Test Program to include evaluation of Salmonella occurrence and regrowth potential.

Background

In late August and September we received Centridry product data with extremely high Salmonella counts. The unprecedented Salmonella levels resulted in an investigation to determine the cause and appropriate response. The results of the investigation are as follows:

The Centridry product was loaded into a trailer over a three day period from July 14th to July 16th. Each day a sample was composited from the discharge of the Centridry system. On July 17th the trailer was delivered to LRI and the Centridry product was transferred to a compost bin. Both the KC lab and LRI took product samples at this time. There was no microbiology analysis scheduled for the collected sample , but the KC micro lab decided to run some unofficial tests of their own for Salmonella and Fecal Coliforms. The sample was refrigerated over the weekend. The sample was tested on July 20th and Fecal Coliforms were found to meet *Class A* requirements but Salmonella exceeded the measurable range established for the sample. The Micro lab recorded the counts as >1,600 MPN/g wet. At this point Greg Ma issued a Health and Safety Alert to the lab for all personnel who had handled the material. The sample was reprocessed eight days later on July 28th with a result of 130,000 MPN/g wet. The lab's bench data indicated that some die off of the organisms had occurred at that point so the initial count could have been measurably higher.

Because of the unusually high Salmonella counts the lab then decided to test the three refrigerated, composite samples taken between July 14th and 16th as well as the sample collected by LRI on the day of product delivery . The LRI collected sample had not been maintained under refrigerated conditions. They found that the first two composite samples (July 14th and 15th) met Class A standards and the third composite (July 16th) and LRI sample had Salmonella counts of 46,000 MPN/g wet and 15,000 mpn/g wet, respectively. For comparison, raw sludge (secondary/primary blend) Salmonella counts have been between 4 and 17 MPN/g wet in the past 5 months.

A group consisting of Greg Ma, Debbie Turner, Ray McClain, and Katherine Bourbonais from the KC Environmental Lab and Bob Bucher, Sue Hennig and Roberta King met to discuss the sample results.
The group agreed to the following:

- KC micro lab had never seen salmonella counts at this level.
- It would be difficult , if not impossible to contaminate a sample to this degree by mishandling the collection.
- There was no obvious explanation for the high salmonella values.
- Product wetting and subsequent regrowth was considered a potential cause.
- More extensive testing is necessary to evaluate product handling and potential causes for the elevated salmonella counts.

What does this mean?

Mark Meckes from the Pathogen Equivalency Committee and Kyle Dorsey of DOE biosolids program were contacted. Both agreed:

- The high counts are not considered a violation, it is a Class B product (because Fecal Coliforms are within limits).
- It is necessary with any biosolids meeting Class B or less to inform subsequent processors of proper hygiene.
- It is not a problem if the end product that will be given away meets Class A standards. Kyle wasn't sure what to say about land application of it as a Class B product.
- If a composter practices proper hygiene (washes hands, no open sores, etc.) the high counts should not be a problem. The concern is if individuals are not careful.
- Respirators should be used, as with any compost facility operation.

Recommendation

More thorough testing of the final Centridry product is necessary to determine how to prevent conditions which may create regrowth potential. This may involve a variety of handling scenarios, such as leaving it sit for periods , etc. It is recommended that these types of studies be incorporated into the proposed extension to the Centridry testing program.

Table C-3: Salmonella and Fecal Coliform Data

Date	Sample Identification	Sample Collection	Total Solids (%)	Salmonellae MPN/100 g wet wgt.	Salmonellae MPN/4 g dry wgt.	Fecal Coliform MPN/100 g wet wgt.	Fecal Coliform MPN/4 g dry wgt.
14-Jul-98	Centridry Product - composite sample during operation	Humboldt	-	< 3	-	ND	-
15-Jul-98	Centridry Product - composite sample during operation	Humboldt	-	< 3	-	ND	-
16-Jul-98	Centridry Product - composite sample during operation	Humboldt	*50.1	46,000	3,680	ND	-
17-Jul-98	Centridry Product - composited grab sample at delivery to LRI	Environmental Lab	50.1	130,000	10,400	2,500	400
17-Jul-98	Centridry Product - grab sample at delivery to LRI	LRI	*50.1	15,000	400	ND	-
For Comparison:							
1-Jul-97	Centridry Product - composite sample during operation	ESRP Operations	75.4	< 2	-	< 20	-
1-Jul-97	Centridry Product - composite sample during operation	ESRP Operations	84.8	< 2	-	< 20	-
15-Sep-97	Centridry Product - composite sample during operation	ESRP Operations	55.7	< 5	-	25,295	1,817
12-Jan-98	Centridry Product - composite sample during operation	ESRP Operations	68.4	< 5	-	347	21
19-Jan-98	Centridry Product - composite sample during operation	ESRP Operations	68.9	< 4	-	42	3
26-Jan-98	Centridry Product - composite sample during operation	ESRP Operations	54.9	< 4	-	177	13
2-Feb-98	Centridry Product - composite sample during operation	ESRP Operations	66.3	< 5	-	7,287	440
23-Feb-98	Centridry Product - composite sample during operation	ESRP Operations	60.1	< 5	-	2,037	136
2-Mar-98	Centridry Product - composite sample during operation	ESRP Operations	52.8	< 8	-	1,284	98
16-Mar-98	Centridry Product - composite sample during operation	ESRP Operations	59.5	< 5	-	870	59
23-Mar-98	Centridry Product - grab sample during undigested sludge processing	ESRP Operations	45.6	9.3	1	> 6.49e5	> 5.69e4
Feb-98	Raw Sludge - composite sample	ESRP Operations	2.67	10	15	2.30e8	3.40e8
Mar-98	Raw Sludge - composite sample	ESRP Operations	4.53	8	7.2	1.70e8	1.50e8
Apr-98	Raw Sludge - composite sample	ESRP Operations	2.59	17	26	3.00e8	4.80e8
May-98	Raw Sludge - composite sample	ESRP Operations	3.74	8	8.4	8.00e6	8.40e6
Jun-98	Raw Sludge - composite sample	ESRP Operations	2.59	4	6	2.80e8	4.40e8

* The TS data was not available for sample; estimated value taken from samples collected during same time interval.

TAB

D

APPENDIX D

CENTRIDRY™ PRODUCT ODOR CHARACTERIZATION TESTS
(AUGUST 1999)

1999 Testing

7/13 Centridry odor analyses: Four buckets.

Bucket test method:

Centridry product (50% solids) was sealed in 6-gallon buckets to compare three possible storage conditions. Cake solids from the Renton belt presses were also tested for comparison. The conditions were:

1. Centridry product aerated
2. Centridry product unaerated and unamended
3. Centridry product unaerated and treated with lime (10% by weight)
4. Cake solids

The buckets were stored at 20 °C.

Gas samples were pulled from the bucket headspaces on day 0 and day 4 for analysis by gas chromatography.

The data tables are:

- Organic compounds, t=0, t=4 days
- Tentatively identified compounds, t=0, t=4 days

7/13 bucket test gas sample - Organics

PROJECT: 423163-49

	Locator: PRODUCT	Locator: I5001
Descrip:	Centridry Product	Renton cake solids
Client Loc:	t=0	t=0
Sampled:	Jul 15, 1999	Jul 15, 1999
Lab ID:	L15920-6	L15920-7
Matrix:	AMBIENTAIR	AMBIENTAIR
% Solids:		

Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			- Wet Weight Basis					- Wet Weight Basis			
M=OR EPA TO-15 (7-3-08-001)											
1,1,1-Trichloroethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,1,2,2-Tetrachloroethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,1,2-Trichloroethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,1,2-Trichloroethylene			<MDL	4	8	ppbv		<MDL	4	8	ppbv
1,1-Dichloroethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,1-Dichloroethylene			<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2,4-Trichlorobenzene			<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2,4-Trimethylbenzene		6.82		2	4	ppbv	14.9		2	4	ppbv
1,2-Dibromoethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2-Dichlorobenzene			<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2-Dichloroethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2-Dichloropropane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,3,5-Trimethylbenzene		4	RDL	2	4	ppbv	7.88		2	4	ppbv
1,3-Dichlorobenzene			<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,4-Dichlorobenzene		5.3		2	4	ppbv	14.6		2	4	ppbv
2-Butanone (MEK)	737	2050	>MR	2	4	ppbv	51.7		2	4	ppbv
4-Ethyltoluene		2.5	<RDL	2	4	ppbv	4.9		2	4	ppbv
4-Methyl-2-Pentanone (MIBK)			<MDL	4	8	ppbv	4.1	<RDL	4	8	ppbv
Acetone		4180	>MR	2	4	ppbv	110		2	4	ppbv
A-Chlorotoluene			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Benzene		11.3		2	4	ppbv	6.5		2	4	ppbv
Bromodichloromethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Bromoform			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Bromomethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Carbon Tetrachloride			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Chlorobenzene			<MDL	2	4	ppbv	9.38		2	4	ppbv
Chlorodibromomethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Chloroethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Chloroform			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Chloromethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Cis-1,2-Dichloroethylene			<MDL	2	4	ppbv	6.76		2	4	ppbv
Cis-1,3-Dichloropropene			<MDL	4	8	ppbv		<MDL	4	8	ppbv
Dichlorodifluoromethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Dichlorotetrafluoroethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Ethylbenzene		6.5		2	4	ppbv	16.5		2	4	ppbv
Hexachlorobutadiene			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Methylene Chloride			<MDL	2	4	ppbv	3.8	<RDL	2	4	ppbv
Styrene			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Tetrachloroethylene			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Toluene		371		2	4	ppbv	196		2	4	ppbv
Total Xylenes		34.2		2	4	ppbv	53.8		2	4	ppbv
Trans-1,2-Dichloroethylene			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Trans-1,3-Dichloropropene			<MDL	4	8	ppbv		<MDL	4	8	ppbv
Trichlorofluoromethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Trichlorotrifluoroethane			<MDL	2	4	ppbv		<MDL	2	4	ppbv
Vinyl Chloride			<MDL	2	4	ppbv		<MDL	2	4	ppbv

* Not converted to dry weight basis for this parameter

7/13 bucket test gas sample - Organics

PROJECT: 423163-49

	Sample 1	Sample 2	Sample 3	Sample 4
Locator:	NONE	NONE	NONE	NONE
Descrip:	Centridry product aerated	Centridry product unaerate	Centridry product + lime	cake solids
Client Loc:	t=4 days	t=4 days	t=4 days	t=4 days
Sampled:	Jul 19, 1999	Jul 19, 1999	Jul 19, 1999	Jul 19, 1999
Lab ID:	L15921-1	L15921-3	L15921-5	L15921-7
Matrix:	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR
% Solids:				

Parameters	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
		-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis			
M=OR EPA TO-15 (7-3-08-001)																				
1,1,1-Trichloroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,1,2,2-Tetrachloroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,1,2-Trichloroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,1,2-Trichloroethylene		<MDL	4	8	ppbv		<MDL	4	8	ppbv		<MDL	4	8	ppbv		<MDL	4	8	ppbv
1,1-Dichloroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,1-Dichloroethylene		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2,4-Trichlorobenzene		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2,4-Trimethylbenzene		<MDL	2	4	ppbv	3.5	<RDL	2	4	ppbv	3.1	<RDL	2	4	ppbv	7.02		2	4	ppbv
1,2-Dibromoethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2-Dichlorobenzene		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2-Dichloroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2-Dichloropropane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,3,5-Trimethylbenzene		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv	3.6	<RDL	2	4	ppbv
1,3-Dichlorobenzene		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,4-Dichlorobenzene		<MDL	2	4	ppbv	2.8	<RDL	2	4	ppbv		<MDL	2	4	ppbv	4.9		2	4	ppbv
2-Butanone (MEK)	38.7		2	4	ppbv	1620	>MR	2	4	ppbv	2250	>MR	2	4	ppbv	88.2		2	4	ppbv
4-Ethyltoluene		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv	2.5	<RDL	2	4	ppbv
4-Methyl-2-Pentanone (MIBK)		<MDL	4	8	ppbv		<MDL	4	8	ppbv		<MDL	4	8	ppbv		<MDL	4	8	ppbv
Acetone	72.8		2	4	ppbv	2670	>MR	2	4	ppbv	3800	>MR	2	4	ppbv	102		2	4	ppbv
A-Chlorotoluene		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Benzene		<MDL	2	4	ppbv	7.46		2	4	ppbv	20.3		2	4	ppbv	6.66		2	4	ppbv
Bromodichloromethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Bromoform		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Bromomethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Carbon Tetrachloride		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Chlorobenzene		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Chlorodibromomethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Chloroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Chloroform		<MDL	2	4	ppbv		<MDL	2	4	ppbv	18.3		2	4	ppbv		<MDL	2	4	ppbv
Chloromethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Cis-1,2-Dichloroethylene		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv	5.92		2	4	ppbv
Cis-1,3-Dichloropropene		<MDL	4	8	ppbv		<MDL	4	8	ppbv		<MDL	4	8	ppbv		<MDL	4	8	ppbv
Dichlorodifluoromethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Dichlorotetrafluoroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Ethylbenzene		<MDL	2	4	ppbv	2.9	<RDL	2	4	ppbv	4.92		2	4	ppbv	12		2	4	ppbv
Hexachlorobutadiene		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Methylene Chloride		<MDL	2	4	ppbv		<MDL	2	4	ppbv	3.8	<RDL	2	4	ppbv		<MDL	2	4	ppbv
Styrene		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Tetrachloroethylene		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Toluene	12.4		2	4	ppbv	50.5		2	4	ppbv	616	>MR	2	4	ppbv	674	>MR	2	4	ppbv
Total Xylenes	4.64		2	4	ppbv	13.9		2	4	ppbv	33.4		2	4	ppbv	48.4		2	4	ppbv
Trans-1,2-Dichloroethylene		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Trans-1,3-Dichloropropene		<MDL	4	8	ppbv		<MDL	4	8	ppbv		<MDL	4	8	ppbv		<MDL	4	8	ppbv
Trichlorofluoromethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Trichlorotrifluoroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Vinyl Chloride		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv		<MDL	2	4	ppbv

* Not converted to dry weight basis for this parameter

PROJECT: 423163-49

7/13 bucket test gas sample - TIC-tentativelyIDed compounds

	Locator: PRODUCT	Locat I5001
	Descrip: Centridry Product	Descr Renton cake solids
	Client Loc: t=0	Client t=0
	Sampled: Jul 15, 1999	Samp Jul 15, 1999
	Lab ID: L15920-6	Lab IL L15920-7
	Matrix: AMBIENTAIR	Matrix AMBIENTAIR
	% Solids:	% Solids:

Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			- Wet Weight Basis					- Wet Weight Basis			
TIC DATA											
M=TI EPA TO-15 (7-3-08-001)											
.alpha.-Pinene(CAS#80-56-8)											
.ALPHA.-PINENE, (-)-(CAS#80-56-8)		29	J2			ppbv	41	J2			ppbv
.beta.-Pinene(CAS#127-91-3)							59	J2			ppbv
1-Butanol, 2-methyl-(CAS#137-32-6)											
1-Butene(CAS#106-98-9)		371	J2			ppbv	80	J2			ppbv
1-Butene, 2-methyl-(CAS#563-46-2)											
1-Ethyl-3-methylcyclohexane (c,t)(CAS#3728-55-0)		21	J2			ppbv					
1-Octanol, 2-butyl-(CAS#3913-02-8)											
1-Pentene(CAS#109-67-1)		72	J2			ppbv					
1-Pentene, 2,4,4-trimethyl-(CAS#107-39-1)											
1-Propanol, 2-methyl-(CAS#78-83-1)		129	J2			ppbv					
1-Propanone, 2-chloro-1-(2,5-dimeth(CAS#54965-52-5)											
1-Propene, 2-methyl-(CAS#115-11-7)		582	J2			ppbv	104	J2			ppbv
2,4-Dimethyl-1-heptene(CAS#19549-87-2)											
2-.BETA.-PINENE(CAS#127-91-3)											
2-Butanol(CAS#78-92-2)											
2-Butanone, 3-methyl-(CAS#563-80-4)											
2-Butene, (E)-(CAS#624-64-6)											
2-Butene, (Z)-(CAS#590-18-1)											
2-Pentanone(CAS#107-87-9)											
2-Propanethiol(CAS#75-33-2)											
3,6,9-Trioxa-2,10-disilaundecane, 2(CAS#16654-74-3)											
3-Ethyl-2-methyl-1-heptene(CAS#19780-60-0)											
3-Pentanone, 2-methyl-(CAS#565-69-5)											
Anthracene, 9,10-Dihydro-9,10-Bis(T(CAS#56272-38-9)		122	J2			ppbv					
Benzene, 1-methyl-2-(1-methylethyl)(CAS#527-84-4)		153	J2			ppbv	260	J2			ppbv
Butanal, 3-methyl-(CAS#590-86-3)		421	J2			ppbv					
Butane(CAS#106-97-8)		192	J2			ppbv	85	J2			ppbv
Butane, 2-cyclopropyl-(CAS#5750-02-7)		25	J2			ppbv					
Carbon disulfide(CAS#75-15-0)	7.7	717	J2			ppbv	73	J2			ppbv
Cyclohexane, (1-methylethyl)-(CAS#696-29-7)											
Cyclohexane, 1,1-dimethyl-2-propyl-(CAS#81983-71-3)											
Cyclohexane, 1,2,3-trimethyl-(CAS#1678-97-3)		70	J2			ppbv	29	J2			ppbv
Cyclohexane, 1,2,3-trimethyl-, (1.a(CAS#7667-55-2)											
Cyclohexane, 1,2,4-trimethyl-(CAS#2234-75-5)							11	J2			ppbv
Cyclohexane, 1-ethyl-2-methyl-(CAS#3728-54-9)							31	J2			ppbv
Cyclohexane, 1-methyl-3-(1-methylet(CAS#16580-24-8)											
Cyclohexane, 1-methyl-4-(1-methylet(CAS#1124-27-2)											
Cyclohexane, methyl-(CAS#108-87-2)											
Cyclohexane, propyl-(CAS#1678-92-8)							99	J2			ppbv
Cyclopentane, 1,1,3,3-tetramethyl-(CAS#50876-33-0)											
Cyclopentane, 1,2,3-trimethyl-, (1.(CAS#2613-69-6)											
Cyclopropane, 1,2-dimethyl-, cis-(CAS#930-18-7)											
Cyclopropane, 1-methyl-2-pentyl-(CAS#41977-37-1)											
Cyclotrisiloxane, hexamethyl-(CAS#541-05-9)		29	J2			ppbv					
Decane(CAS#124-18-5)											
Decane, 2,2,8-trimethyl-(CAS#62238-01-1)											
Decane, 2,2-dimethyl-(CAS#17302-37-3)		103	J2			ppbv					
Decane, 4-methyl-(CAS#2847-72-5)							25	J2			ppbv

7/13 bucket test gas sample - TIC-tentativelyIDed compounds

PROJECT: 423163-49

		Locator: PRODUCT Descrip: Centridry Product Client Loc: t=0 Sampled: Jul 15, 1999 Lab ID: L15920-6 Matrix: AMBIENTAIR % Solids:					Locat: I5001 Descr Renton cake solids Client t=0 Samp Jul 15, 1999 Lab ID L15920-7 Matrix AMBIENTAIR % Solids:				
Parameters	Detection Threshold	Value	Qual	MDL - Wet Weight Basis	RDL	Units	Value	Qual	MDL - Wet Weight Basis	RDL	Units
TIC DATA											
Dimethyl sulfide(CAS#75-18-3)	0.98	23	J2			ppbv	13	J2			ppbv
Disiloxane, hexamethyl-(CAS#107-46-0)											
Disulfide, dimethyl(CAS#624-92-0)	0.026	15	J2			ppbv	3	J2			ppbv
D-Limonene(CAS#5989-27-5)											
dl-Limonene(CAS#138-86-3)											
Ethanol(CAS#64-17-5)		94	J2			ppbv					
Furan, 2-methyl-(CAS#534-22-5)		114	J2			ppbv					
Furan, 3-methyl-(CAS#930-27-8)											
Heptane(CAS#142-82-5)		28	J2			ppbv					
Heptane, 2,2,4,6,6-pentamethyl-(CAS#13475-82-6)		46	J2			ppbv	45	J2			ppbv
Heptane, 2,2-dimethyl-(CAS#1071-26-7)											
Heptane, 2-methyl-(CAS#592-27-8)		24	J2			ppbv					
Heptane, 3-ethyl-2-methyl-(CAS#14676-29-0)		22	J2			ppbv	23	J2			ppbv
Heptane, 3-methylene-(CAS#1632-16-2)											
Hexane(CAS#110-54-3)		48	J2			ppbv					
Hexane, 2,2,5,5-tetramethyl-(CAS#1071-81-4)											
Hexane, 2,2,5-trimethyl-(CAS#3522-94-9)		86	J2			ppbv	73	J2			ppbv
Hexatriacontane(CAS#630-06-8)											
Isobutane(CAS#75-28-5)							129	J2			ppbv
Methanethiol(CAS#74-93-1)	0.021										
Naphthalene, decahydro-, trans-(CAS#493-02-7)											
Nonane(CAS#111-84-2)		39	J2			ppbv	73	J2			ppbv
Nonane, 3-methyl-(CAS#5911-04-6)							35	J2			ppbv
Nonane, 3-methyl-5-propyl-(CAS#31081-18-2)		99	J2			ppbv	95	J2			ppbv
Octane(CAS#111-65-9)		50	J2			ppbv	35	J2			ppbv
Octane, 2,2,6-trimethyl-(CAS#62016-28-8)											
Octane, 2,2-dimethyl-(CAS#15869-87-1)											
Octane, 3-methyl-(CAS#2216-33-3)		23	J2			ppbv	16	J2			ppbv
Octane, 4-methyl-(CAS#2216-34-4)											
Pentane(CAS#109-66-0)		158	J2			ppbv	36	J2			ppbv
Pentane, 2,2,3,4-tetramethyl-(CAS#1186-53-4)											
Pentane, 2,2,4-trimethyl-(CAS#540-84-1)											
Pentane, 2-methyl-(CAS#107-83-5)											
Perfluorotributylamine(CAS#311-89-7)											
Propane, 2-nitro-(CAS#79-46-9)											
Propene(CAS#115-07-1)		742	J2			ppbv	379	J2			ppbv
Silanol, trimethyl-(CAS#1066-40-6)											
Tridecane(CAS#629-50-5)											
Trimethylamine(CAS#75-50-3)	0.046										
Trisiloxane, 1,1,3,3,5,5-hexamethyl(CAS#1189-93-1)											

7/13 bucket test gas sample - TIC-tentativelyIDed compounds

PROJECT: 423163-49

	Sample 1	Sample 2	Sample 3	Sample 4
Locator:	NONE	NONE	NONE	NONE
Descrip:	Centridry product aerated	Centridry product unaera	Centridry product + lime	cake solids
Client Loc:	t=4 days	t=4 days	t=4 days	t=4 days
Sampled:	Jul 19, 1999	Jul 19, 1999	Jul 19, 1999	Jul 19, 1999
Lab ID:	L15921-1	L15921-3	L15921-5	L15921-7
Matrix:	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR
% Solids:				

Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis			
TIC DATA																					
M=TI EPA TO-15 (7-3-08-001)																					
.alpha.-Pinene(CAS#80-56-8)												16	J2			ppbv	33	J2			ppbv
.ALPHA.-PINENE, (-)-(CAS#80-56-8)							13	J2			ppbv										
.beta.-Pinene(CAS#127-91-3)							17	J2			ppbv	14	J2			ppbv	35	J2			ppbv
1-Butanol, 2-methyl-(CAS#137-32-6)												28	J2			ppbv					
1-Butene(CAS#106-98-9)							229	J2			ppbv	212	J2			ppbv	50	J2			ppbv
1-Butene, 2-methyl-(CAS#563-46-2)																	36	J2			ppbv
1-Ethyl-3-methylcyclohexane (c,t)(CAS#3728-55-0)																	25	J2			ppbv
1-Octanol, 2-butyl-(CAS#3913-02-8)							11	J2			ppbv										
1-Pentene(CAS#109-67-1)							38	J2			ppbv										
1-Pentene, 2,4,4-trimethyl-(CAS#107-39-1)																	11	J2			ppbv
1-Propanol, 2-methyl-(CAS#78-83-1)							24	J2			ppbv										
1-Propanone, 2-chloro-1-(2,5-dimeth(CAS#54965-52-5)							43	J3			ppbv										
1-Propene, 2-methyl-(CAS#115-11-7)							547	J2			ppbv	837	J2			ppbv	240	J2			ppbv
2,4-Dimethyl-1-heptene(CAS#19549-87-2)												18	J2			ppbv					
2-.BETA.-PINENE(CAS#127-91-3)																	14	J2			ppbv
2-Butanol(CAS#78-92-2)												61	J2			ppbv					
2-Butanone, 3-methyl-(CAS#563-80-4)							8	J2			ppbv	16	J2			ppbv					
2-Butene, (E)-(CAS#624-64-6)																	195	J2			ppbv
2-Butene, (Z)-(CAS#590-18-1)		13	J2			ppbv	127	J2			ppbv										
2-Pentanone(CAS#107-87-9)							25	J2			ppbv	45	J2			ppbv					
2-Propanethiol(CAS#75-33-2)																	18	J2			ppbv
3,6,9-Trioxa-2,10-disilaundecane, 2(CAS#16654-74-3)		15	J3			ppbv															
3-Ethyl-2-methyl-1-heptene(CAS#19780-60-0)																	78	J2			ppbv
3-Pentanone, 2-methyl-(CAS#565-69-5)												17	J2			ppbv					
Anthracene, 9,10-Dihydro-9,10-Bis(T(CAS#56272-38-9)		35	J2			ppbv	49	J2			ppbv	36	J2			ppbv	99	J2			ppbv
Benzene, 1-methyl-2-(1-methylethyl)(CAS#527-84-4)							76	J2			ppbv	54	J2			ppbv	131	J2			ppbv
Butanal, 3-methyl-(CAS#590-86-3)							23	J2			ppbv										
Butane(CAS#106-97-8)							151	J2			ppbv						161	J2			ppbv
Butane, 2-cyclopropyl-(CAS#5750-02-7)							18	J2			ppbv						27	J2			ppbv
Carbon disulfide(CAS#75-15-0)	7.7	27	J2			ppbv	215	J2			ppbv										
Cyclohexane, (1-methylethyl)-(CAS#696-29-7)																	24	J3			ppbv
Cyclohexane, 1,1-dimethyl-2-propyl-(CAS#81983-71-3)												18	J2			ppbv					
Cyclohexane, 1,2,3-trimethyl-(CAS#1678-97-3)																	28	J2			ppbv
Cyclohexane, 1,2,3-trimethyl-, (1.a(CAS#7667-55-2)																	14	J2			ppbv
Cyclohexane, 1,2,4-trimethyl-(CAS#2234-75-5)																	16	J2			ppbv
Cyclohexane, 1-ethyl-2-methyl-(CAS#3728-54-9)																	27	J2			ppbv
Cyclohexane, 1-methyl-3-(1-methylet(CAS#16580-24-8)																	15	J2			ppbv
Cyclohexane, 1-methyl-4-(1-methylet(CAS#1124-27-2)																	11	J2			ppbv
Cyclohexane, methyl-(CAS#108-87-2)																	9	J2			ppbv
Cyclohexane, propyl-(CAS#1678-92-8)																	68	J3			ppbv
Cyclopentane, 1,1,3,3-tetramethyl-(CAS#50876-33-0)																	14	J2			ppbv
Cyclopentane, 1,2,3-trimethyl-, (1.(CAS#2613-69-6)																	46	J2			ppbv
Cyclopropane, 1,2-dimethyl-, cis-(CAS#930-18-7)																	20	J2			ppbv
Cyclopropane, 1-methyl-2-pentyl-(CAS#41977-37-1)																	14	J2			ppbv
Cyclotrisiloxane, hexamethyl-(CAS#541-05-9)		9	J2			ppbv	12	J2			ppbv										
Decane(CAS#124-18-5)							42	J2			ppbv						75	J2			ppbv
Decane, 2,2,8-trimethyl-(CAS#62238-01-1)							15	J2			ppbv										
Decane, 2,2-dimethyl-(CAS#17302-37-3)												37	J2			ppbv					
Decane, 4-methyl-(CAS#2847-72-5)																	12	J2			ppbv

7/13 bucket test gas sample - TIC-tentativelyIDed compounds

PROJECT: 423163-49

		Locator:	NONE				Locator:	NONE				Locator:	NONE				Locator:	NONE			
		Descrip:	Centridry product aerated				Descrip:	Centridry product unaera				Descrip:	Centridry product + lime				Descrip:	cake solids			
		Client Loc:	t=4 days				Client Loc:	t=4 days				Client Loc:	t=4 days				Client Loc:	t=4 days			
		Sampled:	Jul 19, 1999				Sampled:	Jul 19, 1999				Sampled:	Jul 19, 1999				Sampled:	Jul 19, 1999			
		Lab ID:	L15921-1				Lab ID:	L15921-3				Lab ID:	L15921-5				Lab ID:	L15921-7			
		Matrix:	AMBIENTAIR				Matrix:	AMBIENTAIR				Matrix:	AMBIENTAIR				Matrix:	AMBIENTAIR			
		% Solids:					% Solids:					% Solids:					% Solids:				
Parameters	Detection Threshold	Value	Qual	MDL -Wet Weight Basis	RDL	Units	Value	Qual	MDL -Wet Weight Basis	RDL	Units	Value	Qual	MDL -Wet Weight Basis	RDL	Units	Value	Qual	MDL -Wet Weight Basis	RDL	Units
TIC DATA																					
Dimethyl sulfide(CAS#75-18-3)	0.98	1	J2			ppbv	24	J2			ppbv	140	J2			ppbv	4	J2			ppbv
Disiloxane, hexamethyl-(CAS#107-46-0)												22	J2			ppbv					
Disulfide, dimethyl(CAS#624-92-0)	0.026	13	J2			ppbv	18	J2			ppbv	35	J2			ppbv					
D-Limonene(CAS#5989-27-5)																	67	J2			ppbv
dl-Limonene(CAS#138-86-3)							50	J2			ppbv										
Ethanol(CAS#64-17-5)							939	J2			ppbv	139	J2			ppbv					
Furan, 2-methyl-(CAS#534-22-5)							65	J2			ppbv	44	J2			ppbv					
Furan, 3-methyl-(CAS#930-27-8)							84	J2			ppbv										
Heptane(CAS#142-82-5)							15	J2			ppbv	18	J2			ppbv	13	J2			ppbv
Heptane, 2,2,4,6,6-pentamethyl-(CAS#13475-82-6)							19	J2			ppbv						15	J2			ppbv
Heptane, 2,2-dimethyl-(CAS#1071-26-7)							43	J2			ppbv										
Heptane, 2-methyl-(CAS#592-27-8)							11	J2			ppbv	12	J2			ppbv					
Heptane, 3-ethyl-2-methyl-(CAS#14676-29-0)																	15	J2			ppbv
Heptane, 3-methylene-(CAS#1632-16-2)												15	J2			ppbv					
Hexane(CAS#110-54-3)							35	J2			ppbv						28	J2			ppbv
Hexane, 2,2,5,5-tetramethyl-(CAS#1071-81-4)												19	J2			ppbv					
Hexane, 2,2,5-trimethyl-(CAS#3522-94-9)												29	J2			ppbv	98	J2			ppbv
Hexatriacontane(CAS#630-06-8)							20	J2			ppbv										
Isobutane(CAS#75-28-5)							261	J2			ppbv										
Methanethiol(CAS#74-93-1)	0.021																195	J2			ppbv
Naphthalene, decahydro-, trans-(CAS#493-02-7)																	22	J2			ppbv
Nonane(CAS#111-84-2)							16	J2			ppbv	26	J2			ppbv	56	J2			ppbv
Nonane, 3-methyl-(CAS#5911-04-6)												16	J2			ppbv	19	J2			ppbv
Nonane, 3-methyl-5-propyl-(CAS#31081-18-2)							42	J2			ppbv	36	J2			ppbv	50	J2			ppbv
Octane(CAS#111-65-9)							27	J2			ppbv	33	J2			ppbv	96	J2			ppbv
Octane, 2,2,6-trimethyl-(CAS#62016-28-8)												16	J2			ppbv					
Octane, 2,2-dimethyl-(CAS#15869-87-1)							60	J2			ppbv										
Octane, 3-methyl-(CAS#2216-33-3)												10	J2			ppbv	17	J2			ppbv
Octane, 4-methyl-(CAS#2216-34-4)												12	J2			ppbv	17	J2			ppbv
Pentane(CAS#109-66-0)							164	J2			ppbv	160	J2			ppbv	88	J2			ppbv
Pentane, 2,2,3,4-tetramethyl-(CAS#1186-53-4)												37	J2			ppbv					
Pentane, 2,2,4-trimethyl-(CAS#540-84-1)																	12	J2			ppbv
Pentane, 2-methyl-(CAS#107-83-5)							28	J2			ppbv										
Perfluorotributylamine(CAS#311-89-7)							20	J2			ppbv										
Propane, 2-nitro-(CAS#79-46-9)												19	J2			ppbv					
Propene(CAS#115-07-1)							734	J2			ppbv						789	J2			ppbv
Silanol, trimethyl-(CAS#1066-40-6)												213	J2			ppbv					
Tridecane(CAS#629-50-5)												8	J2			ppbv					
Trimethylamine(CAS#75-50-3)	0.046											2530	J2			ppbv					
Trisiloxane, 1,1,3,3,5,5-hexamethyl(CAS#1189-93-1)		34	J3			ppbv											71	J3			ppbv

1999 Testing

8/3 Centridry odor analyses: Four buckets.

Bucket test method:

Centridry product (50% solids) was sealed in 6-gallon buckets to compare three possible storage conditions. Cake solids from the Renton belt presses were also tested for comparison. The conditions were:

1. Centridry product aerated
2. Centridry product unaerated and unamended
3. Centridry product unaerated and treated with lime (10% by weight)
4. Cake solids

The buckets were stored at 40 °C.

Gas samples were pulled from the bucket headspaces on days 0, 4, and 15 for analysis by gas chromatography and odor panel.

The data includes:

- Data tables, organic compounds, t=0, t=4, t=15 days
- Data tables, tentatively identified compounds, t=0, t=4, t=15 days
- Graphs of changes in concentration over time for eight compounds that may be significant contributors to Centridry odor
- Odor panel results

8/3 bucket test gas sample - Organics

PROJECT: 423163-49

	Product sample	Renton cake solids sample
Locator:	PRODUCT	NONE
Descrip:	Centridry Product	Renton cake solids
Client Loc:	t=0	t=0
Sampled:	Aug 03, 1999	Aug 03, 1999
Lab ID:	L16092-1	L16092-2
Matrix:	AMBIENTAIR	AMBIENTAIR
% Solids:		

Parameters	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
		-Wet Weight Basis					-Wet Weight Basis			
M=OR EPA TO-15 (7-3-08-001)										
1,1,1-Trichloroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,1,2,2-Tetrachloroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,1,2-Trichloroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,1,2-Trichloroethylene		<MDL	4	8	ppbv		<MDL	4	8	ppbv
1,1-Dichloroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,1-Dichloroethylene		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2,4-Trichlorobenzene		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2,4-Trimethylbenzene	9.32		2	4	ppbv	19.2		2	4	ppbv
1,2-Dibromoethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2-Dichlorobenzene		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2-Dichloroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,2-Dichloropropane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,3,5-Trimethylbenzene	4.74		2	4	ppbv	9.1		2	4	ppbv
1,3-Dichlorobenzene		<MDL	2	4	ppbv		<MDL	2	4	ppbv
1,4-Dichlorobenzene	7.3		2	4	ppbv	18.7		2	4	ppbv
2-Butanone (MEK)	1470	>MR	2	4	ppbv	61.6		2	4	ppbv
4-Ethyltoluene	3.2	<RDL	2	4	ppbv	4.52		2	4	ppbv
4-Methyl-2-Pentanone (MIBK)		<MDL	4	8	ppbv	5.9	<RDL	4	8	ppbv
Acetone	2820	>MR	2	4	ppbv	119		2	4	ppbv
A-Chlorotoluene		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Benzene	11.8		2	4	ppbv	7.18		2	4	ppbv
Bromodichloromethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Bromoform		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Bromomethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Carbon Tetrachloride		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Chlorobenzene	6.62		2	4	ppbv	24.5		2	4	ppbv
Chlorodibromomethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Chloroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Chloroform		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Chloromethane	4.9		2	4	ppbv		<MDL	2	4	ppbv
Cis-1,2-Dichloroethylene		<MDL	2	4	ppbv	8.86		2	4	ppbv
Cis-1,3-Dichloropropene		<MDL	4	8	ppbv		<MDL	4	8	ppbv
Dichlorodifluoromethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Dichlorotetrafluoroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Ethylbenzene	9.42		2	4	ppbv	23.4		2	4	ppbv
Hexachlorobutadiene		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Methylene Chloride		<MDL	2	4	ppbv	4.46		2	4	ppbv
Styrene		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Tetrachloroethylene		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Toluene	386	>MR	2	4	ppbv	365	>MR	2	4	ppbv
Total Xylenes	29.8		2	4	ppbv	57.4		2	4	ppbv
Trans-1,2-Dichloroethylene		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Trans-1,3-Dichloropropene		<MDL	4	8	ppbv		<MDL	4	8	ppbv
Trichlorofluoromethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Trichlorotrifluoroethane		<MDL	2	4	ppbv		<MDL	2	4	ppbv
Vinyl Chloride		<MDL	2	4	ppbv		<MDL	2	4	ppbv
M=TI EPA TO-15 (7-3-08-001)										
Pyridine	11	J2			ppbv					
Isopropyl Alcohol										
2-Propanol										

8/3 bucket test gas sample - Organics

PROJECT: 423163-49

	Sample 1	Sample 2	Sample 3	Sample 4
Locator:	NONE	NONE	NONE	NONE
Descrip:	Centridry product aerated	Centridry product unaerat		cake solids
Client Loc:	t=4 days	t=4 days	t=4 days	t=4 days
Sampled:	Aug 06, 1999	Aug 06, 1999	Aug 06, 1999	Aug 06, 1999
Lab ID:	L16093-2	L16093-3	L16093-4	L16093-1
Matrix:	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR
% Solids:				

Parameters	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
		-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis			
M=OR EPA TO-15 (7-3-08-001)																				
1,1,1-Trichloroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
1,1,2,2-Tetrachloroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
1,1,2-Trichloroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
1,1,2-Trichloroethylene		<MDL	4	8	ppbv		<MDL	40	80	ppbv		<MDL	40	80	ppbv		<MDL	4	8	ppbv
1,1-Dichloroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
1,1-Dichloroethylene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
1,2,4-Trichlorobenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
1,2,4-Trimethylbenzene	3.4	<RDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv	57.2		2	4	ppbv
1,2-Dibromoethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
1,2-Dichlorobenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
1,2-Dichloroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
1,2-Dichloropropane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
1,3,5-Trimethylbenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv	29.3		2	4	ppbv
1,3-Dichlorobenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
1,4-Dichlorobenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv	43		2	4	ppbv
2-Butanone (MEK)	1980	>MR	2	4	ppbv	3930	>MR	20	40	ppbv	6560	>MR	20	40	ppbv	658	>MR	2	4	ppbv
4-Ethyltoluene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv	14.8		2	4	ppbv
4-Methyl-2-Pentanone (MIBK)	26.4		4	8	ppbv		<MDL	40	80	ppbv	113		40	80	ppbv		<MDL	4	8	ppbv
Acetone	3910	>MR	2	4	ppbv	11500	>MR	20	40	ppbv	14700	>MR	20	40	ppbv	568	>MR	2	4	ppbv
A-Chlorotoluene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Benzene	10.8		2	4	ppbv		<MDL	20	40	ppbv	65.6		20	40	ppbv	25.9		2	4	ppbv
Bromodichloromethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Bromoform		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Bromomethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Carbon Tetrachloride		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Chlorobenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv	78.8		2	4	ppbv
Chlorodibromomethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Chloroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Chloroform		<MDL	2	4	ppbv		<MDL	20	40	ppbv	43.6		20	40	ppbv		<MDL	2	4	ppbv
Chloromethane	8.26	B	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Cis-1,2-Dichloroethylene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv	16.9		2	4	ppbv
Cis-1,3-Dichloropropene		<MDL	4	8	ppbv		<MDL	40	80	ppbv		<MDL	40	80	ppbv		<MDL	4	8	ppbv
Dichlorodifluoromethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Dichlorotetrafluoroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Ethylbenzene	3.1	<RDL	2	4	ppbv		<MDL	20	40	ppbv	21	<RDL	20	40	ppbv	87.4		2	4	ppbv
Hexachlorobutadiene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Methylene Chloride		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Styrene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv	4	RDL	2	4	ppbv
Tetrachloroethylene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv	2.7	<RDL	2	4	ppbv
Toluene	133		2	4	ppbv	347		20	40	ppbv	5970	>MR	20	40	ppbv	1670	>MR	2	4	ppbv
Total Xylenes	17.6		2	4	ppbv		<MDL	20	40	ppbv	98.6		20	40	ppbv	245		2	4	ppbv
Trans-1,2-Dichloroethylene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Trans-1,3-Dichloropropene		<MDL	4	8	ppbv		<MDL	40	80	ppbv		<MDL	40	80	ppbv		<MDL	4	8	ppbv
Trichlorofluoromethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Trichlorotrifluoroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
Vinyl Chloride		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	2	4	ppbv
M=TI EPA TO-15 (7-3-08-001)																				
Pyridine																				
Isopropyl Alcohol	280	J2			ppbv	3900	J2			ppbv						45	J2			ppbv
2-Propanol																				

8/3 bucket test gas sample - Organics

PROJECT: 423163-49

	Sample 1	Sample 2	Sample 3	Sample 4
Locator:	NONE	NONE	NONE	NONE
Descrip:	Centridry product aerated	Centridry product unaerat	Centridry product + lime	cake solids
Client Loc:	T=15 days	T=15 days	T=15 days	T=15 days
Sampled:	Aug 17, 1999	Aug 17, 1999	Aug 17, 1999	Aug 17, 1999
Lab ID:	L16212-1	L16212-2	L16212-3	L16212-4
Matrix:	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR
% Solids:				

Parameters	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
		-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis			
M=OR EPA TO-15 (7-3-08-001)																				
1,1,1-Trichloroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
1,1,2,2-Tetrachloroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
1,1,2-Trichloroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
1,1,2-Trichloroethylene		<MDL	4	8	ppbv		<MDL	40	80	ppbv		<MDL	40	80	ppbv		<MDL	13	26.7	ppbv
1,1-Dichloroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
1,1-Dichloroethylene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
1,2,4-Trichlorobenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
1,2,4-Trimethylbenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv	8.6	<RDL	6.7	13.3	ppbv
1,2-Dibromoethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
1,2-Dichlorobenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
1,2-Dichloroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
1,2-Dichloropropane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
1,3,5-Trimethylbenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
1,3-Dichlorobenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
1,4-Dichlorobenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
2-Butanone (MEK)	40.9		2	4	ppbv	6090	>MR	20	40	ppbv	7610	>MR	20	40	ppbv	1240	>MR	6.7	13.3	ppbv
4-Ethyltoluene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
4-Methyl-2-Pentanone (MIBK)		<MDL	4	8	ppbv	336		40	80	ppbv		<MDL	40	80	ppbv	99.3		13	26.7	ppbv
Acetone	138	>MR	2	4	ppbv	18000	>MR	20	40	ppbv	13400	>MR	20	40	ppbv	2780	>MR	6.7	13.3	ppbv
A-Chlorotoluene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Benzene		<MDL	2	4	ppbv	38	<RDL	20	40	ppbv	85.6		20	40	ppbv	15		6.7	13.3	ppbv
Bromodichloromethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Bromoform		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Bromomethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Carbon Tetrachloride		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Chlorobenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv	13.9		6.7	13.3	ppbv
Chlorodibromomethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Chloroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Chloroform		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Chloromethane	2.2	<RDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Cis-1,2-Dichloroethylene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Cis-1,3-Dichloropropene		<MDL	4	8	ppbv		<MDL	40	80	ppbv		<MDL	40	80	ppbv		<MDL	13	26.7	ppbv
Dichlorodifluoromethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Dichlorotetrafluoroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Ethylbenzene		<MDL	2	4	ppbv		<MDL	20	40	ppbv	33	<RDL	20	40	ppbv	21.1		6.7	13.3	ppbv
Hexachlorobutadiene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Methylene Chloride		<MDL	2	4	ppbv	41.6		20	40	ppbv	35	<RDL	20	40	ppbv	13.5		6.7	13.3	ppbv
Styrene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Tetrachloroethylene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Toluene	4.16		2	4	ppbv	928		20	40	ppbv	10400	>MR	20	40	ppbv	1660	>MR	6.7	13.3	ppbv
Total Xylenes		<MDL	2	4	ppbv	33	<RDL	20	40	ppbv	183		20	40	ppbv	61.4		6.7	13.3	ppbv
Trans-1,2-Dichloroethylene		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Trans-1,3-Dichloropropene		<MDL	4	8	ppbv		<MDL	40	80	ppbv		<MDL	40	80	ppbv		<MDL	13	26.7	ppbv
Trichlorofluoromethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Trichlorotrifluoroethane		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
Vinyl Chloride		<MDL	2	4	ppbv		<MDL	20	40	ppbv		<MDL	20	40	ppbv		<MDL	6.7	13.3	ppbv
M=TI EPA TO-15 (7-3-08-001)																				
Pyridine																				
Isopropyl Alcohol						18000	J2			ppbv						88	J2			ppbv
2-Propanol											310	J2			ppbv					

8/3 bucket test gas sample - TIC-tentatively IDed compounds

PROJECT: 423163-49

		Locator: NONE Descrip: Centridry product Client Loc: T=0 days Sampled: Aug 03, 1999 Lab ID: L16092-1 Matrix: AMBIENTAIR % Solids:					Locator: NONE Descrip: Renton cake solids Client Loc: T=0 days Sampled: Aug 03, 1999 Lab ID: L16092-2 Matrix: AMBIENTAIR % Solids:				
Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis			
TIC DATA											
M=TI EPA TO-15 (7-3-08-001)											
.alpha.-Pinene, (-)-(CAS#80-56-8)		35	J2			ppbv	90	J2			ppbv
.beta.-Pinene(CAS#127-91-3)		35	J2			ppbv	89	J2			ppbv
.Delta.3-Carene(CAS#13466-78-9)		16	J2			ppbv					
1,1,4-Trimethylcyclohexane(CAS#7094-27-1)											
1,3-Butadiene, 2-methyl-(CAS#78-79-5)											
1,3-Pentadiene, (E)-(CAS#2004-70-8)											
1-Azabicyclo[2.2.2]octan-3-one(CAS#3731-38-2)							33	J2			ppbv
1-Butanol(CAS#71-36-3)											
1-Butanol, 2-ethyl-(CAS#97-95-0)											
1-Butene(CAS#106-98-9)		322	J2			ppbv	46	J2			ppbv
1-Decene, 3,4-dimethyl-(CAS#50871-03-9)		14	J2			ppbv					
1-Ethyl-3-methylcyclohexane (c,t)(CAS#3728-55-0)							22	J2			ppbv
1-Heptene, 5-methyl-(CAS#13151-04-7)											
1-Nonanol, 4,8-dimethyl-(CAS#33933-80-1)							142	J2			ppbv
1-Pentanethiol(CAS#110-66-7)											
1-Pentene(CAS#109-67-1)		41	J2			ppbv					
1-Pentene, 2,4,4-trimethyl-(CAS#107-39-1)											
1-Propanol(CAS#71-23-8)											
1-Propanol, 2-methyl-(CAS#78-83-1)											
1-Propene(CAS#115-07-1)											
1-Propene, 2-methyl-(CAS#115-11-7)		508	J2			ppbv	184	J2			ppbv
2,4-Dimethyl-1-heptene(CAS#19549-87-2)											
2-Butanethiol(CAS#513-53-1)											
2-Butanol(CAS#78-92-2)											
2-Butanone, 3-methyl-(CAS#563-80-4)											
2-Hexanone, 5-methyl-(CAS#110-12-3)											
2-Hexene(CAS#592-43-8)											
2-Nonene, (E)-(CAS#6434-78-2)											
2-Pentanol(CAS#6032-29-7)											
2-Pentanone(CAS#107-87-9)		26	J2			ppbv					
2-Pentanone, 3-methyl-(CAS#565-61-7)											
2-Propanethiol(CAS#75-33-2)											
2-Propanethiol, 2-methyl-(CAS#75-66-1)											
2-Propanol(CAS#67-63-0)											
2-Propen-1-ol(CAS#107-18-6)											
2-Pyrrolidinone, 1-ethenyl-(CAS#88-12-0)							28	J3			ppbv
2H-Pyran, 3,4-dihydro-(CAS#110-87-2)		53	J3			ppbv					
3,3,3-D3-Pyruvic Acid Oxime 2TMS(CAS#0-00-0)											
3-Ethyl-4-methyl-2-pentene(CAS#19780-68-8)											
3-Heptene, 2,6-dimethyl-(CAS#2738-18-3)											
3-Heptene, 4-ethyl-(CAS#33933-74-3)		20	J2			ppbv					
3-Heptene, 4-methyl-(CAS#4485-16-9)											
3-Pentanone(CAS#96-22-0)											
3-Phenylindole(CAS#1504-16-1)											
4-Octen-3-one(CAS#14129-48-7)							45	J2			ppbv
4-Penten-2-one(CAS#13891-87-7)											
5-Hepten-2-one, 6-methyl-(CAS#110-93-0)											
9-Oxabicyclo[6.1.0]nonane, 1-methyl(CAS#52954-47-9)							51	J3			ppbv

8/3 bucket test gas sample - TIC-tentatively IDed compounds

PROJECT: 423163-49

		Sample 1					Sample 2				
Locator:		NONE					NONE				
Descrip:		Centridry product					Renton cake solids				
Client Loc:		T=0 days					T=0 days				
Sampled:		Aug 03, 1999					Aug 03, 1999				
Lab ID:		L16092-1					L16092-2				
Matrix:		AMBIENTAIR					AMBIENTAIR				
% Solids:											
Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis			
TIC DATA											
Acetaldehyde(CAS#75-07-0)											
Acetamide, 2,2,2-trifluoro-N,N-bis((CAS#21149-38-2)											
Acetonitrile(CAS#75-05-8)											
Anthracene, 9,10-Dihydro-9,10-Bis(T(CAS#56272-38-9)							66	J2			ppbv
Benzene, 1-methyl-2-(1-methylethyl)(CAS#527-84-4)		113	J2			ppbv	285	J2			ppbv
Butanal, 2-methyl-(CAS#96-17-3)		81	J2			ppbv					
Butanal, 3-methyl-(CAS#590-86-3)		158	J2			ppbv					
Butane(CAS#106-97-8)		220	J2			ppbv	83	J2			ppbv
Butane, 2-cyclopropyl-(CAS#5750-02-7)		27	J2			ppbv					
Butanoic acid, 3-methyl-, ethyl est(CAS#108-64-5)											
Carbon disulfide(CAS#75-15-0)	7.7	644	J2			ppbv	91	J2			ppbv
Carbon oxide sulfide (COS)(CAS#463-58-1)											
cis-1-Ethyl-3-methyl-cyclohexane(CAS#19489-10-2)											
Cyclobutane, 2-ethyl-1-methyl-3-pro(CAS#61233-72-5)		43	J3			ppbv					
Cyclohexane(CAS#110-82-7)											
Cyclohexane, (1-methylethyl)-(CAS#696-29-7)											
Cyclohexane, (3,3-dimethylpentyl)-(CAS#61142-22-1)		13	J2			ppbv					
Cyclohexane, 1,1,2-trimethyl-(CAS#7094-26-0)											
Cyclohexane, 1,1,3-trimethyl-(CAS#3073-66-3)											
Cyclohexane, 1,1-dimethyl-(CAS#590-66-9)											
Cyclohexane, 1,2,3-trimethyl-(CAS#1678-97-3)							14	J3			ppbv
Cyclohexane, 1,2,3-trimethyl-, (1.a(CAS#1678-81-5)											
Cyclohexane, 1,2,4-trimethyl-(CAS#2234-75-5)		12	J2			ppbv	16	J2			ppbv
Cyclohexane, 1,3,5-trimethyl-(CAS#1839-63-0)											
Cyclohexane, 1,3,5-trimethyl-, (1.a(CAS#1795-26-2)							36	J2			ppbv
Cyclohexane, 1,3-dimethyl-, cis-(CAS#638-04-0)											
Cyclohexane, 1,4-dimethyl-(CAS#589-90-2)											
Cyclohexane, 1,4-dimethyl-, trans-(CAS#2207-04-7)		22	J2			ppbv					
Cyclohexane, 1-bromo-4-methyl-(CAS#6294-40-2)		12	J2			ppbv					
Cyclohexane, 1-ethyl-2-methyl-, tra(CAS#4923-78-8)							73	J2			ppbv
Cyclohexane, 1-ethyl-4-methyl-, cis(CAS#4926-78-7)											
Cyclohexane, 1-ethyl-4-methyl-, tra(CAS#6236-88-0)											
Cyclohexane, 1-methyl-3-propyl-(CAS#4291-80-9)							68	J2			ppbv
Cyclohexane, 1-methyl-4-(1-methylet(CAS#1879-07-8)											
Cyclohexane, 1-methyl-4-(1-methylet(CAS#6069-98-3)											
Cyclohexane, butyl-(CAS#1678-93-9)							46	J2			ppbv
Cyclohexane, ethyl-(CAS#1678-91-7)											
Cyclohexane, methyl-(CAS#108-87-2)		75	J2			ppbv					
Cyclohexane, propyl-(CAS#1678-92-8)											
Cyclohexanone, 2,3-dimethyl-(CAS#13395-76-1)							154	J2			ppbv
Cyclopentane, 1,1,3,3-tetramethyl-(CAS#50876-33-0)		15	J2			ppbv	14	J2			ppbv
Cyclopentane, 1,2,3-trimethyl-, (1.(CAS#2613-69-6)							43	J3			ppbv
Cyclopentane, 1-methyl-3-(2-methylp(CAS#29053-04-1)							43	J2			ppbv
Cyclopentane, methylene-(CAS#1528-30-9)		13	J2			ppbv					
Cyclopropane, 1,1-dimethyl-(CAS#1630-94-0)											
Cyclopropane, 1,2-dimethyl-, cis-(CAS#930-18-7)											
Cyclopropane, 1,2-dimethyl-, trans-(CAS#2402-06-4)											
Cyclotrisiloxane, hexamethyl-(CAS#541-05-9)											
D-Limonene(CAS#5989-27-5)		97	J2			ppbv	189	J2			ppbv

8/3 bucket test gas sample - TIC-tentatively IDed compounds

PROJECT: 423163-49

		Locator: NONE Descrip: Centridry product Client Loc: T=0 days Sampled: Aug 03, 1999 Lab ID: L16092-1 Matrix: AMBIENTAIR % Solids:					Locator: NONE Descrip: Renton cake solids Client Loc: T=0 days Sampled: Aug 03, 1999 Lab ID: L16092-2 Matrix: AMBIENTAIR % Solids:				
Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis			
TIC DATA											
Decane(CAS#124-18-5)							119	J2			ppbv
Decane, 2,2,8-trimethyl-(CAS#62238-01-1)											
Decane, 2,2,9-trimethyl-(CAS#62238-00-0)											
Decane, 2,2-dimethyl-(CAS#17302-37-3)											
Decane, 2,5,6-trimethyl-(CAS#62108-23-0)		93	J2			ppbv					
Decane, 3,3,4-trimethyl-(CAS#49622-18-6)											
Decane, 3-methyl-(CAS#13151-34-3)											
Diisooctyl Sulfate(CAS#0-00-0)		49	J2			ppbv					
Dimethyl sulfide(CAS#75-18-3)	0.98	18	J2			ppbv	31	J2			ppbv
Dimethyl-3,5 Heptene-3(CAS#0-00-0)											
Disiloxane, hexamethyl-(CAS#107-46-0)											
Disulfide, dimethyl(CAS#624-92-0)	0.026	34	J2			ppbv	3	J2			ppbv
dl-Limonene(CAS#138-86-3)											
Dodecane(CAS#112-40-3)											
Ethanethioic acid, S-methyl ester(CAS#1534-08-3)											
Ethanethiol(CAS#75-08-1)	0.0128										
Ethanol(CAS#64-17-5)											
Ether, heptyl hexyl(CAS#7289-40-9)							29	J2			ppbv
Ethyl Acetate(CAS#141-78-6)											
Furan, 2-methyl-(CAS#534-22-5)		71	J2			ppbv					
Furan, 3-methyl-(CAS#930-27-8)											
Heptane(CAS#142-82-5)		43	J2			ppbv					
Heptane, 2,2,4,6,6-pentamethyl-(CAS#13475-82-6)		19	J2			ppbv					
Heptane, 2,2-dimethyl-(CAS#1071-26-7)											
Heptane, 2,3-dimethyl-(CAS#3074-71-3)											
Heptane, 2,4-dimethyl-(CAS#2213-23-2)											
Heptane, 2,5-dimethyl-(CAS#2216-30-0)											
Heptane, 2-methyl-(CAS#592-27-8)		29	J2			ppbv	11	J2			ppbv
Heptane, 3-ethyl-2-methyl-(CAS#14676-29-0)		19	J2			ppbv	53	J2			ppbv
Heptane, 3-methyl-(CAS#589-81-1)		11	J2			ppbv	10	J2			ppbv
Heptane, 4-ethyl-2,2,6,6-tetramethy(CAS#62108-31-0)		24	J2			ppbv					
Hexane(CAS#110-54-3)		64	J2			ppbv					
Hexane, 2,2,4-trimethyl-(CAS#16747-26-5)											
Hexane, 2,2,5,5-tetramethyl-(CAS#1071-81-4)							14	J3			ppbv
Hexane, 2,2,5-trimethyl-(CAS#3522-94-9)		67	J2			ppbv	82	J2			ppbv
Hexane, 2,3,4-trimethyl-(CAS#921-47-1)							27	J2			ppbv
Hexane, 2,3-dimethyl-(CAS#584-94-1)											
Hexane, 2,4-dimethyl-(CAS#589-43-5)		19	J2			ppbv					
Hexane, 2,5-dimethyl-(CAS#592-13-2)		16	J2			ppbv					
Hexane, 2-methyl-(CAS#591-76-4)											
Hexane, 3,3-dimethyl-(CAS#563-16-6)							29	J2			ppbv
Hexane, 3,4-dimethyl-(CAS#583-48-2)											
Hexane, 3-ethyl-2-methyl-(CAS#16789-46-1)											
Hexane, 3-methyl-(CAS#589-34-4)											
Hexanoic acid, 3-hexenyl ester, (Z)(CAS#31501-11-8)											
Isobutane(CAS#75-28-5)		549	J2			ppbv	156	J2			ppbv
Isooctane (CAS#26635-64-3)											
Isopropyl Alcohol(CAS#67-63-0)											
Limonene(CAS#138-86-3)											

8/3 bucket test gas sample - TIC-tentatively IDed compounds

PROJECT: 423163-49

		Locator: NONE Descrip: Centridry product Client Loc: T=0 days Sampled: Aug 03, 1999 Lab ID: L16092-1 Matrix: AMBIENTAIR % Solids:					Locator: NONE Descrip: Renton cake solids Client Loc: T=0 days Sampled: Aug 03, 1999 Lab ID: L16092-2 Matrix: AMBIENTAIR % Solids:				
Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis			
TIC DATA											
Methallylcyclohexane(CAS#0-00-0)							68	J2			ppbv
Methanethiol(CAS#74-93-1)	0.021										
Naphthalene, decahydro-, trans-(CAS#493-02-7)							75	J2			ppbv
Nonane(CAS#111-84-2)		44	J2			ppbv	119	J2			ppbv
Nonane, 3-methyl-(CAS#5911-04-6)		11	J2			ppbv	67	J2			ppbv
Nonane, 3-methyl-5-propyl-(CAS#31081-18-2)		70	J2			ppbv	112	J2			ppbv
Nonane, 4-methyl-5-propyl-(CAS#62185-55-1)											
Nonane, 5-methyl-(CAS#15869-85-9)											
Octane(CAS#111-65-9)		45	J2			ppbv	29	J2			ppbv
Octane, 2,6-dimethyl-(CAS#2051-30-1)											
Octane, 2-methyl-(CAS#3221-61-2)											
Octane, 3-methyl-(CAS#2216-33-3)		16	J2			ppbv	25	J2			ppbv
Octane, 4,5-dimethyl-(CAS#15869-96-2)											
Octane, 4-methyl-(CAS#2216-34-4)		17	J2			ppbv					
Pentane(CAS#109-66-0)		163	J2			ppbv	29	J2			ppbv
Pentane, 2,2,4-trimethyl-(CAS#540-84-1)											
Pentane, 2,3,4-trimethyl-(CAS#565-75-3)											
Pentane, 2,3-dimethyl-(CAS#565-59-3)											
Pentane, 3,3-dimethyl-(CAS#562-49-2)											
Pentane, 3-methyl-(CAS#96-14-0)											
Propanal, 2-methyl-(CAS#78-84-2)		233	J2			ppbv					
Propanal, 2-propenylhydrazone(CAS#19031-78-8)											
Propane, 2-methyl-(CAS#75-28-5)											
Propene(CAS#115-07-1)		687	J2			ppbv	608	J2			ppbv
Pyridine(CAS#110-86-1)		11	J2			ppbv					
Silanol, trimethyl-(CAS#1066-40-6)											
Sulfide, allyl methyl(CAS#10152-76-8)											
Thiirane, methyl-(CAS#1072-43-1)											
Trans Nonene-3(CAS#0-00-0)		13	J2			ppbv					
Tridecane, 3-methylene-(CAS#19780-34-8)							30	J3			ppbv
Trimethylamine(CAS#75-50-3)	0.046										
Trisulfide, dimethyl(CAS#3658-80-8)	1.220										
Undecane(CAS#1120-21-4)		13	J2			ppbv	31	J2			ppbv
Undecane, 2,8-dimethyl-(CAS#17301-25-6)		14	J2			ppbv					
Unknown(CAS#74685-31-7)		56	J3			ppbv	32	J2			ppbv
Unknown(CAS#SCAN#)		56	J3			ppbv	32	J2			ppbv

8/3 bucket test gas sample - TIC-tentatively IDed compounds

PROJECT: 423163-49

	L16093-2	L16093-3	L16093-4	L16093-1
Locator:	NONE	NONE	NONE	NONE
Descrip:	Centridry product aerated	Centridry product unaerate	Centridry + lime	Renton cake solids
Client Loc:	T=4 days	T=4 days	T=4 days	T=4 days
Sampled:	Aug 06, 1999	Aug 06, 1999	Aug 06, 1999	Aug 06, 1999
Lab ID:	L16093-2	L16093-3	L16093-4	L16093-1
Matrix:	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR
% Solids:				

Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis			
TIC DATA																					
M=TI EPA TO-15 (7-3-08-001)																					
.alpha.-Pinene, (-)-(CAS#80-56-8)																	50	J2			ppbv
.beta.-Pinene(CAS#127-91-3)												297	J2			ppbv	45	J2			ppbv
.Delta.3-Carene(CAS#13466-78-9)																					
1,1,4-Trimethylcyclohexane(CAS#7094-27-1)																					
1,3-Butadiene, 2-methyl-(CAS#78-79-5)																	21	J2			ppbv
1,3-Pentadiene, (E)-(CAS#2004-70-8)		235	J2			ppbv															
1-Azabicyclo[2.2.2]octan-3-one(CAS#3731-38-2)																					
1-Butanol(CAS#71-36-3)												4000	J2			ppbv					
1-Butanol, 2-ethyl-(CAS#97-95-0)																	26	J2			ppbv
1-Butene(CAS#106-98-9)																					
1-Decene, 3,4-dimethyl-(CAS#50871-03-9)																					
1-Ethyl-3-methylcyclohexane (c,t)(CAS#3728-55-0)																					
1-Heptene, 5-methyl-(CAS#13151-04-7)																					
1-Nonanol, 4,8-dimethyl-(CAS#33933-80-1)																					
1-Pentanethiol(CAS#110-66-7)																	21	J2			ppbv
1-Pentene(CAS#109-67-1)																					
1-Pentene, 2,4,4-trimethyl-(CAS#107-39-1)																	28	J2			ppbv
1-Propanol(CAS#71-23-8)							229	J2			ppbv										
1-Propanol, 2-methyl-(CAS#78-83-1)							277	J2			ppbv	141	J2			ppbv					
1-Propene(CAS#115-07-1)																					
1-Propene, 2-methyl-(CAS#115-11-7)		671	J2			ppbv	625	J2			ppbv	843	J2			ppbv	201	J2			ppbv
2,4-Dimethyl-1-heptene(CAS#19549-87-2)																	59	J2			ppbv
2-Butanethiol(CAS#513-53-1)																	45	J2			ppbv
2-Butanol(CAS#78-92-2)		25	J2			ppbv	1170	J2			ppbv										
2-Butanone, 3-methyl-(CAS#563-80-4)		34	J2			ppbv															
2-Hexanone, 5-methyl-(CAS#110-12-3)																					
2-Hexene(CAS#592-43-8)																					
2-Nonene, (E)-(CAS#6434-78-2)																	28	J3			ppbv
2-Pentanol(CAS#6032-29-7)																					
2-Pentanone(CAS#107-87-9)		30	J2			ppbv	143	J2			ppbv	176	J2			ppbv					
2-Pentanone, 3-methyl-(CAS#565-61-7)		17	J2			ppbv															
2-Propanethiol(CAS#75-33-2)																	132	J2			ppbv
2-Propanethiol, 2-methyl-(CAS#75-66-1)																	52	J2			ppbv
2-Propanol(CAS#67-63-0)																					
2-Propen-1-ol(CAS#107-18-6)																					
2-Pyrrolidinone, 1-ethenyl-(CAS#88-12-0)																	23	J3			ppbv
2H-Pyran, 3,4-dihydro-(CAS#110-87-2)																					
3,3,3-D3-Pyruvic Acid Oxime 2TMS(CAS#0-00-0)							357	J2			ppbv										
3-Ethyl-4-methyl-2-pentene(CAS#19780-68-8)												613	J3			ppbv					
3-Heptene, 2,6-dimethyl-(CAS#2738-18-3)																	12	J2			ppbv
3-Heptene, 4-ethyl-(CAS#33933-74-3)																					
3-Heptene, 4-methyl-(CAS#4485-16-9)																					
3-Pentanone(CAS#96-22-0)		109	J2			ppbv															
3-Phenylindole(CAS#1504-16-1)																					
4-Octen-3-one(CAS#14129-48-7)																					
4-Penten-2-one(CAS#13891-87-7)		18	J3			ppbv															
5-Hepten-2-one, 6-methyl-(CAS#110-93-0)		14	J2			ppbv															
9-Oxabicyclo[6.1.0]nonane, 1-methyl(CAS#52954-47-9)																					

8/3 bucket test gas sample - TIC-tentatively IDed compounds

PROJECT: 423163-49

		Locator:	NONE				Locator:	NONE				Locator:	NONE				Locator:	NONE			
		Descrip:	Centridry product aerated				Descrip:	Centridry product unaerate				Descrip:	Centridry + lime				Descrip:	Renton cake solids			
		Client Loc:	T=4 days				Client Loc:	T=4 days				Client Loc:	T=4 days				Client Loc:	T=4 days			
		Sampled:	Aug 06, 1999				Sampled:	Aug 06, 1999				Sampled:	Aug 06, 1999				Sampled:	Aug 06, 1999			
		Lab ID:	L16093-2				Lab ID:	L16093-3				Lab ID:	L16093-4				Lab ID:	L16093-1			
		Matrix:	AMBIENTAIR				Matrix:	AMBIENTAIR				Matrix:	AMBIENTAIR				Matrix:	AMBIENTAIR			
		% Solids:					% Solids:					% Solids:					% Solids:				
Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis			
TIC DATA																					
Acetaldehyde(CAS#75-07-0)																					
Acetamide, 2,2,2-trifluoro-N,N-bis((CAS#21149-38-2)							220	J2			ppbv										
Acetonitrile(CAS#75-05-8)												160	J2			ppbv					
Anthracene, 9,10-Dihydro-9,10-Bis(T(CAS#56272-38-9)		74	J2			ppbv	2630	J2			ppbv	523	J2			ppbv	31	J2			ppbv
Benzene, 1-methyl-2-(1-methylethyl)(CAS#527-84-4)		46	J2			ppbv						890	J2			ppbv	108	J2			ppbv
Butanal, 2-methyl-(CAS#96-17-3)		11	J2			ppbv															
Butanal, 3-methyl-(CAS#590-86-3)		26	J2			ppbv															
Butane(CAS#106-97-8)		376	J2			ppbv						143	J2			ppbv	75	J2			ppbv
Butane, 2-cyclopropyl-(CAS#5750-02-7)																					
Butanoic acid, 3-methyl-, ethyl est(CAS#108-64-5)																					
Carbon disulfide(CAS#75-15-0)	7.7	391	J2			ppbv	569	J2			ppbv										
Carbon oxide sulfide (COS)(CAS#463-58-1)																					
cis-1-Ethyl-3-methyl-cyclohexane(CAS#19489-10-2)																	37	J2			ppbv
Cyclobutane, 2-ethyl-1-methyl-3-pro(CAS#61233-72-5)																					
Cyclohexane(CAS#110-82-7)																	33	J2			ppbv
Cyclohexane, (1-methylethyl)-(CAS#696-29-7)																	45	J2			ppbv
Cyclohexane, (3,3-dimethylpentyl)-(CAS#61142-22-1)																					
Cyclohexane, 1,1,2-trimethyl-(CAS#7094-26-0)																	97	J3			ppbv
Cyclohexane, 1,1,3-trimethyl-(CAS#3073-66-3)												417	J2			ppbv	46	J2			ppbv
Cyclohexane, 1,1-dimethyl-(CAS#590-66-9)																	76	J2			ppbv
Cyclohexane, 1,2,3-trimethyl-(CAS#1678-97-3)																					
Cyclohexane, 1,2,3-trimethyl-, (1.a(CAS#1678-81-5)																	48	J2			ppbv
Cyclohexane, 1,2,4-trimethyl-(CAS#2234-75-5)																					
Cyclohexane, 1,3,5-trimethyl-(CAS#1839-63-0)																	36	J2			ppbv
Cyclohexane, 1,3,5-trimethyl-, (1.a(CAS#1795-26-2)																					
Cyclohexane, 1,3-dimethyl-, cis-(CAS#638-04-0)		12	J2			ppbv						1570	J2			ppbv	115	J2			ppbv
Cyclohexane, 1,4-dimethyl-(CAS#589-90-2)																					
Cyclohexane, 1,4-dimethyl-, trans-(CAS#2207-04-7)																					
Cyclohexane, 1-bromo-4-methyl-(CAS#6294-40-2)																					
Cyclohexane, 1-ethyl-2-methyl-, tra(CAS#4923-78-8)																	18	J2			ppbv
Cyclohexane, 1-ethyl-4-methyl-, cis(CAS#4926-78-7)																	62	J2			ppbv
Cyclohexane, 1-ethyl-4-methyl-, tra(CAS#6236-88-0)																	15	J2			ppbv
Cyclohexane, 1-methyl-3-propyl-(CAS#4291-80-9)																					
Cyclohexane, 1-methyl-4-(1-methylet(CAS#1879-07-8)																	15	J2			ppbv
Cyclohexane, 1-methyl-4-(1-methylet(CAS#6069-98-3)																					
Cyclohexane, butyl-(CAS#1678-93-9)																					
Cyclohexane, ethyl-(CAS#1678-91-7)		13	J2			ppbv															
Cyclohexane, methyl-(CAS#108-87-2)												800	J2			ppbv	660	J2			ppbv
Cyclohexane, propyl-(CAS#1678-92-8)		19	J2			ppbv											92	J2			ppbv
Cyclohexanone, 2,3-dimethyl-(CAS#13395-76-1)																					
Cyclopentane, 1,1,3,3-tetramethyl-(CAS#50876-33-0)																					
Cyclopentane, 1,2,3-trimethyl-, (1.(CAS#2613-69-6)																					
Cyclopentane, 1-methyl-3-(2-methylp(CAS#29053-04-1)																					
Cyclopentane, methylene-(CAS#1528-30-9)																					
Cyclopropane, 1,1-dimethyl-(CAS#1630-94-0)																					
Cyclopropane, 1,2-dimethyl-, cis-(CAS#930-18-7)																	43	J2			ppbv
Cyclopropane, 1,2-dimethyl-, trans-(CAS#2402-06-4)																	25	J2			ppbv
Cyclotrisiloxane, hexamethyl-(CAS#541-05-9)		14	J2			ppbv															
D-Limonene(CAS#5989-27-5)		20	J2			ppbv															

8/3 bucket test gas sample - TIC-tentatively IDed compounds

PROJECT: 423163-49

		Locator: NONE Descrip: Centridry product aerated Client Loc: T=4 days Sampled: Aug 06, 1999 Lab ID: L16093-2 Matrix: AMBIENTAIR % Solids:					Locator: NONE Descrip: Centridry product unaerate Client Loc: T=4 days Sampled: Aug 06, 1999 Lab ID: L16093-3 Matrix: AMBIENTAIR % Solids:					Locator: NONE Descrip: Centridry + lime Client Loc: T=4 days Sampled: Aug 06, 1999 Lab ID: L16093-4 Matrix: AMBIENTAIR % Solids:					Locator: NONE Descrip: Renton cake solids Client Loc: T=4 days Sampled: Aug 06, 1999 Lab ID: L16093-1 Matrix: AMBIENTAIR % Solids:				
Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis			
TIC DATA																					
Decane(CAS#124-18-5)		46	J2			ppbv						417	J2			ppbv	118	J2			ppbv
Decane, 2,2,8-trimethyl-(CAS#62238-01-1)		22	J2			ppbv	108	J2			ppbv	759	J2			ppbv					
Decane, 2,2,9-trimethyl-(CAS#62238-00-0)																					
Decane, 2,2-dimethyl-(CAS#17302-37-3)		21	J2			ppbv						455	J2			ppbv	15	J2			ppbv
Decane, 2,5,6-trimethyl-(CAS#62108-23-0)		17	J2			ppbv											80	J2			ppbv
Decane, 3,3,4-trimethyl-(CAS#49622-18-6)																					
Decane, 3-methyl-(CAS#13151-34-3)																	56	J2			ppbv
Diisooctyl Sulfate(CAS#0-00-0)																					
Dimethyl sulfide(CAS#75-18-3)	0.98	43	J2			ppbv	120	J2			ppbv	430	J2			ppbv	32	J2			ppbv
Dimethyl-3,5 Heptene-3(CAS#0-00-0)																					
Disiloxane, hexamethyl-(CAS#107-46-0)												406	J2			ppbv					
Disulfide, dimethyl(CAS#624-92-0)	0.026	203	J2			ppbv	1500	J2			ppbv	368	J2			ppbv	33	J2			ppbv
dl-Limonene(CAS#138-86-3)																					
Dodecane(CAS#112-40-3)							114	J2			ppbv										
Ethanethioic acid, S-methyl ester(CAS#1534-08-3)																					
Ethanethiol(CAS#75-08-1)	0.0128																77	J2			ppbv
Ethanol(CAS#64-17-5)		978	J2			ppbv	2550	J2			ppbv	500	J2			ppbv	52	J2			ppbv
Ether, heptyl hexyl(CAS#7289-40-9)																					
Ethyl Acetate(CAS#141-78-6)							143	J2			ppbv										
Furan, 2-methyl-(CAS#534-22-5)		17	J2			ppbv															
Furan, 3-methyl-(CAS#930-27-8)		72	J2			ppbv															
Heptane(CAS#142-82-5)												346	J2			ppbv	231	J2			ppbv
Heptane, 2,2,4,6,6-pentamethyl-(CAS#13475-82-6)																					
Heptane, 2,2-dimethyl-(CAS#1071-26-7)												377	J2			ppbv					
Heptane, 2,3-dimethyl-(CAS#3074-71-3)																	52	J2			ppbv
Heptane, 2,4-dimethyl-(CAS#2213-23-2)												359	J2			ppbv	49	J2			ppbv
Heptane, 2,5-dimethyl-(CAS#2216-30-0)		18	J2			ppbv						523	J2			ppbv	86	J2			ppbv
Heptane, 2-methyl-(CAS#592-27-8)		19	J2			ppbv						1640	J2			ppbv	100	J2			ppbv
Heptane, 3-ethyl-2-methyl-(CAS#14676-29-0)																	31	J2			ppbv
Heptane, 3-methyl-(CAS#589-81-1)		21	J2			ppbv						1580	J2			ppbv	115	J2			ppbv
Heptane, 4-ethyl-2,2,6,6-tetramethy(CAS#62108-31-0)																					
Hexane(CAS#110-54-3)																					
Hexane, 2,2,4-trimethyl-(CAS#16747-26-5)																	54	J2			ppbv
Hexane, 2,2,5,5-tetramethyl-(CAS#1071-81-4)																					
Hexane, 2,2,5-trimethyl-(CAS#3522-94-9)		30	J2			ppbv						1070	J2			ppbv	147	J2			ppbv
Hexane, 2,3,4-trimethyl-(CAS#921-47-1)																					
Hexane, 2,3-dimethyl-(CAS#584-94-1)												391	J2			ppbv					
Hexane, 2,4-dimethyl-(CAS#589-43-5)												258	J2			ppbv	21	J2			ppbv
Hexane, 2,5-dimethyl-(CAS#592-13-2)												177	J2			ppbv	285	J2			ppbv
Hexane, 2-methyl-(CAS#591-76-4)												343	J2			ppbv	97	J2			ppbv
Hexane, 3,3-dimethyl-(CAS#563-16-6)		12	J2			ppbv											31	J2			ppbv
Hexane, 3,4-dimethyl-(CAS#583-48-2)																					
Hexane, 3-ethyl-2-methyl-(CAS#16789-46-1)																					
Hexane, 3-methyl-(CAS#589-34-4)												226	J2			ppbv	185	J2			ppbv
Hexanoic acid, 3-hexenyl ester, (Z)(CAS#31501-11-8)																					
Isobutane(CAS#75-28-5)												512	J2			ppbv	174	J2			ppbv
Isooctane (CAS#26635-64-3)																					
Isopropyl Alcohol(CAS#67-63-0)		280	J2			ppbv	3900	J2			ppbv						45	J2			ppbv
Limonene(CAS#138-86-3)												393	J2			ppbv	88	J2			ppbv

8/3 bucket test gas sample - TIC-tentatively IDed compounds

PROJECT: 423163-49

		Locator: NONE					Locator: NONE					Locator: NONE					Locator: NONE				
		Descrip: Centridry product aerated					Descrip: Centridry product unaerate					Descrip: Centridry + lime					Descrip: Renton cake solids				
		Client Loc: T=4 days					Client Loc: T=4 days					Client Loc: T=4 days					Client Loc: T=4 days				
		Sampled: Aug 06, 1999					Sampled: Aug 06, 1999					Sampled: Aug 06, 1999					Sampled: Aug 06, 1999				
		Lab ID: L16093-2					Lab ID: L16093-3					Lab ID: L16093-4					Lab ID: L16093-1				
		Matrix: AMBIENTAIR					Matrix: AMBIENTAIR					Matrix: AMBIENTAIR					Matrix: AMBIENTAIR				
		% Solids:					% Solids:					% Solids:					% Solids:				
Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis			
TIC DATA																					
Methallylcyclohexane(CAS#0-00-0)																					
Methanethiol(CAS#74-93-1)	0.021	1050	J2			ppbv	10500	J2			ppbv						163	J2			ppbv
Naphthalene, decahydro-, trans-(CAS#493-02-7)																					
Nonane(CAS#111-84-2)		26	J2			ppbv						529	J2			ppbv	89	J2			ppbv
Nonane, 3-methyl-(CAS#5911-04-6)																	16	J2			ppbv
Nonane, 3-methyl-5-propyl-(CAS#31081-18-2)		34	J2			ppbv						728	J2			ppbv					
Nonane, 4-methyl-5-propyl-(CAS#62185-55-1)		16	J2			ppbv															
Nonane, 5-methyl-(CAS#15869-85-9)																	13	J2			ppbv
Octane(CAS#111-65-9)		60	J2			ppbv						2050	J2			ppbv					
Octane, 2,6-dimethyl-(CAS#2051-30-1)												392	J2			ppbv					
Octane, 2-methyl-(CAS#3221-61-2)		33	J2			ppbv															
Octane, 3-methyl-(CAS#2216-33-3)		23	J2			ppbv						447	J2			ppbv	81	J2			ppbv
Octane, 4,5-dimethyl-(CAS#15869-96-2)																	41	J2			ppbv
Octane, 4-methyl-(CAS#2216-34-4)												701	J2			ppbv	113	J2			ppbv
Pentane(CAS#109-66-0)		36	J2			ppbv						212	J2			ppbv	41	J2			ppbv
Pentane, 2,2,4-trimethyl-(CAS#540-84-1)																	62	J2			ppbv
Pentane, 2,3,4-trimethyl-(CAS#565-75-3)												584	J2			ppbv	62	J2			ppbv
Pentane, 2,3-dimethyl-(CAS#565-59-3)																					
Pentane, 3,3-dimethyl-(CAS#562-49-2)																	19	J2			ppbv
Pentane, 3-methyl-(CAS#96-14-0)																					
Propanal, 2-methyl-(CAS#78-84-2)																					
Propanal, 2-propenylhydrazone(CAS#19031-78-8)							132	J2			ppbv										
Propane, 2-methyl-(CAS#75-28-5)							231	J2			ppbv										
Propene(CAS#115-07-1)							1200	J2			ppbv						457	J2			ppbv
Pyridine(CAS#110-86-1)																					
Silanol, trimethyl-(CAS#1066-40-6)												3650	J2			ppbv					
Sulfide, allyl methyl(CAS#10152-76-8)																					
Thiirane, methyl-(CAS#1072-43-1)																					
Trans Nonene-3(CAS#0-00-0)																					
Tridecane, 3-methylene-(CAS#19780-34-8)																					
Trimethylamine(CAS#75-50-3)	0.046	1290	J2			ppbv						12800	J2			ppbv	197	J2			ppbv
Trisulfide, dimethyl(CAS#3658-80-8)	1.220	21	J2			ppbv	223	J2			ppbv										
Undecane(CAS#1120-21-4)		12	J2			ppbv															
Undecane, 2,8-dimethyl-(CAS#17301-25-6)																					
Unknown(CAS#74685-31-7)																					
Unknown(CAS#SCAN#)																					

8/3 bucket test gas sample - TIC-tentatively IDed compounds

PROJECT: 423163-49

	Sample 1	Sample 2	Sample 3	Sample 4
Locator:	NONE	NONE	NONE	NONE
Descrip:	Centridry product aerated	Centridry product unaerate	Centridry + lime	Renton cake solids
Client Loc:	T=15 days	T=15 days	T=15 days	T=15 days
Sampled:	Aug 17, 1999	Aug 17, 1999	Aug 17, 1999	Aug 17, 1999
Lab ID:	L16212-1	L16212-2	L16212-3	L16212-4
Matrix:	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR
% Solids:				

Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis			
TIC DATA																					
M=TI EPA TO-15 (7-3-08-001)																					
.alpha.-Pinene, (-)-(CAS#80-56-8)																	79	J2			ppbv
.beta.-Pinene(CAS#127-91-3)																	78	J2			ppbv
.Delta.3-Carene(CAS#13466-78-9)																					
1,1,4-Trimethylcyclohexane(CAS#7094-27-1)												300	J2			ppbv					
1,3-Butadiene, 2-methyl-(CAS#78-79-5)																					
1,3-Pentadiene, (E)-(CAS#2004-70-8)																					
1-Azabicyclo[2.2.2]octan-3-one(CAS#3731-38-2)																					
1-Butanol(CAS#71-36-3)							270	J2			ppbv	7790	J2			ppbv					
1-Butanol, 2-ethyl-(CAS#97-95-0)																					
1-Butene(CAS#106-98-9)												206	J2			ppbv					
1-Decene, 3,4-dimethyl-(CAS#50871-03-9)																					
1-Ethyl-3-methylcyclohexane (c,t)(CAS#3728-55-0)																					
1-Heptene, 5-methyl-(CAS#13151-04-7)																	78	J2			ppbv
1-Nonanol, 4,8-dimethyl-(CAS#33933-80-1)																					
1-Pentanethiol(CAS#110-66-7)																					
1-Pentene(CAS#109-67-1)																					
1-Pentene, 2,4,4-trimethyl-(CAS#107-39-1)																					
1-Propanol(CAS#71-23-8)																					
1-Propanol, 2-methyl-(CAS#78-83-1)							309	J2			ppbv										
1-Propene(CAS#115-07-1)												2210	J2			ppbv					
1-Propene, 2-methyl-(CAS#115-11-7)		17	J2			ppbv	12700	J2			ppbv	1390	J2			ppbv	791	J2			ppbv
2,4-Dimethyl-1-heptene(CAS#19549-87-2)																					
2-Butanethiol(CAS#513-53-1)							194	J2			ppbv										
2-Butanol(CAS#78-92-2)							4330	J2			ppbv										
2-Butanone, 3-methyl-(CAS#563-80-4)																					
2-Hexanone, 5-methyl-(CAS#110-12-3)																	42	J2			ppbv
2-Hexene(CAS#592-43-8)																	159	J3			ppbv
2-Nonene, (E)-(CAS#6434-78-2)																					
2-Pentanol(CAS#6032-29-7)							285	J2			ppbv										
2-Pentanone(CAS#107-87-9)							947	J2			ppbv						158	J2			ppbv
2-Pentanone, 3-methyl-(CAS#565-61-7)																					
2-Propanethiol(CAS#75-33-2)							9380	J2			ppbv						68	J2			ppbv
2-Propanethiol, 2-methyl-(CAS#75-66-1)							1070	J2			ppbv						84	J2			ppbv
2-Propanol(CAS#67-63-0)												307	J2			ppbv					
2-Propen-1-ol(CAS#107-18-6)												155	J2			ppbv					
2-Pyrrolidinone, 1-ethenyl-(CAS#88-12-0)																					
2H-Pyran, 3,4-dihydro-(CAS#110-87-2)																					
3,3,3-D3-Pyruvic Acid Oxime 2TMS(CAS#0-00-0)																					
3-Ethyl-4-methyl-2-pentene(CAS#19780-68-8)																					
3-Heptene, 2,6-dimethyl-(CAS#2738-18-3)																					
3-Heptene, 4-ethyl-(CAS#33933-74-3)																					
3-Heptene, 4-methyl-(CAS#4485-16-9)							160	J2			ppbv										
3-Pentanone(CAS#96-22-0)																	127	J2			ppbv
3-Phenylindole(CAS#1504-16-1)		15	J3			ppbv	243	J3			ppbv						133	J3			ppbv
4-Octen-3-one(CAS#14129-48-7)																					
4-Penten-2-one(CAS#13891-87-7)																					
5-Hepten-2-one, 6-methyl-(CAS#110-93-0)																					
9-Oxabicyclo[6.1.0]nonane, 1-methyl(CAS#52954-47-9)																					

8/3 bucket test gas sample - TIC-tentatively IDed compounds

PROJECT: 423163-49

		Locator: NONE					Locator: NONE					Locator: NONE					Locator: NONE				
		Descrip: Centridry product aerated					Descrip: Centridry product unaerate					Descrip: Centridry + lime					Descrip: Renton cake solids				
		Client Loc: T=15 days					Client Loc: T=15 days					Client Loc: T=15 days					Client Loc: T=15 days				
		Sampled: Aug 17, 1999					Sampled: Aug 17, 1999					Sampled: Aug 17, 1999					Sampled: Aug 17, 1999				
		Lab ID: L16212-1					Lab ID: L16212-2					Lab ID: L16212-3					Lab ID: L16212-4				
		Matrix: AMBIENTAIR					Matrix: AMBIENTAIR					Matrix: AMBIENTAIR					Matrix: AMBIENTAIR				
		% Solids:					% Solids:					% Solids:					% Solids:				
Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis			
TIC DATA																					
Acetaldehyde(CAS#75-07-0)		63	J2			ppbv						184	J2			ppbv					
Acetamide, 2,2,2-trifluoro-N,N-bis((CAS#21149-38-2)																					
Acetonitrile(CAS#75-05-8)												670	J2			ppbv					
Anthracene, 9,10-Dihydro-9,10-Bis(T(CAS#56272-38-9)		29	J2			ppbv	583	J2			ppbv										
Benzene, 1-methyl-2-(1-methylethyl)(CAS#527-84-4)							218	J2			ppbv						183	J2			ppbv
Butanal, 2-methyl-(CAS#96-17-3)		11	J2			ppbv															
Butanal, 3-methyl-(CAS#590-86-3)		22	J2			ppbv															
Butane(CAS#106-97-8)												375	J2			ppbv					
Butane, 2-cyclopropyl-(CAS#5750-02-7)																	47	J2			ppbv
Butanoic acid, 3-methyl-, ethyl est(CAS#108-64-5)							125	J2			ppbv										
Carbon disulfide(CAS#75-15-0)	7.7	43	J2			ppbv	2670	J2			ppbv										
Carbon oxide sulfide (COS)(CAS#463-58-1)		80	J2			ppbv															
cis-1-Ethyl-3-methyl-cyclohexane(CAS#19489-10-2)																					
Cyclobutane, 2-ethyl-1-methyl-3-pro(CAS#61233-72-5)																					
Cyclohexane(CAS#110-82-7)																					
Cyclohexane, (1-methylethyl)-(CAS#696-29-7)																					
Cyclohexane, (3,3-dimethylpentyl)-(CAS#61142-22-1)																					
Cyclohexane, 1,1,2-trimethyl-(CAS#7094-26-0)																					
Cyclohexane, 1,1,3-trimethyl-(CAS#3073-66-3)																	48	J2			ppbv
Cyclohexane, 1,1-dimethyl-(CAS#590-66-9)												316	J2			ppbv					
Cyclohexane, 1,2,3-trimethyl-(CAS#1678-97-3)																	64	J2			ppbv
Cyclohexane, 1,2,3-trimethyl-, (1.a(CAS#1678-81-5)																					
Cyclohexane, 1,2,4-trimethyl-(CAS#2234-75-5)																					
Cyclohexane, 1,3,5-trimethyl-(CAS#1839-63-0)																					
Cyclohexane, 1,3,5-trimethyl-, (1.a(CAS#1795-26-2)																					
Cyclohexane, 1,3-dimethyl-, cis-(CAS#638-04-0)												773	J2			ppbv	62	J2			ppbv
Cyclohexane, 1,4-dimethyl-(CAS#589-90-2)																	47	J2			ppbv
Cyclohexane, 1,4-dimethyl-, trans-(CAS#2207-04-7)												178	J2			ppbv					
Cyclohexane, 1-bromo-4-methyl-(CAS#6294-40-2)																					
Cyclohexane, 1-ethyl-2-methyl-, tra(CAS#4923-78-8)																					
Cyclohexane, 1-ethyl-4-methyl-, cis(CAS#4926-78-7)																	85	J2			ppbv
Cyclohexane, 1-ethyl-4-methyl-, tra(CAS#6236-88-0)																					
Cyclohexane, 1-methyl-3-propyl-(CAS#4291-80-9)																					
Cyclohexane, 1-methyl-4-(1-methylet(CAS#1879-07-8)																					
Cyclohexane, 1-methyl-4-(1-methylet(CAS#6069-98-3)																	45	J3			ppbv
Cyclohexane, butyl-(CAS#1678-93-9)																					
Cyclohexane, ethyl-(CAS#1678-91-7)												344	J2			ppbv					
Cyclohexane, methyl-(CAS#108-87-2)												2520	J2			ppbv					
Cyclohexane, propyl-(CAS#1678-92-8)																					
Cyclohexanone, 2,3-dimethyl-(CAS#13395-76-1)																					
Cyclopentane, 1,1,3,3-tetramethyl-(CAS#50876-33-0)																					
Cyclopentane, 1,2,3-trimethyl-, (1.(CAS#2613-69-6)																					
Cyclopentane, 1-methyl-3-(2-methylp(CAS#29053-04-1)																					
Cyclopentane, methylene-(CAS#1528-30-9)																					
Cyclopropane, 1,1-dimethyl-(CAS#1630-94-0)																	43	J3			ppbv
Cyclopropane, 1,2-dimethyl-, cis-(CAS#930-18-7)																					
Cyclopropane, 1,2-dimethyl-, trans-(CAS#2402-06-4)																					
Cyclotrisiloxane, hexamethyl-(CAS#541-05-9)																	54	J2			ppbv
D-Limonene(CAS#5989-27-5)																					

8/3 bucket test gas sample - TIC-tentatively IDed compounds

PROJECT: 423163-49

	Sample 1	Sample 2	Sample 3	Sample 4
Locator:	NONE	NONE	NONE	NONE
Descrip:	Centridry product aerated	Centridry product unaerate	Centridry + lime	Renton cake solids
Client Loc:	T=15 days	T=15 days	T=15 days	T=15 days
Sampled:	Aug 17, 1999	Aug 17, 1999	Aug 17, 1999	Aug 17, 1999
Lab ID:	L16212-1	L16212-2	L16212-3	L16212-4
Matrix:	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR
% Solids:				

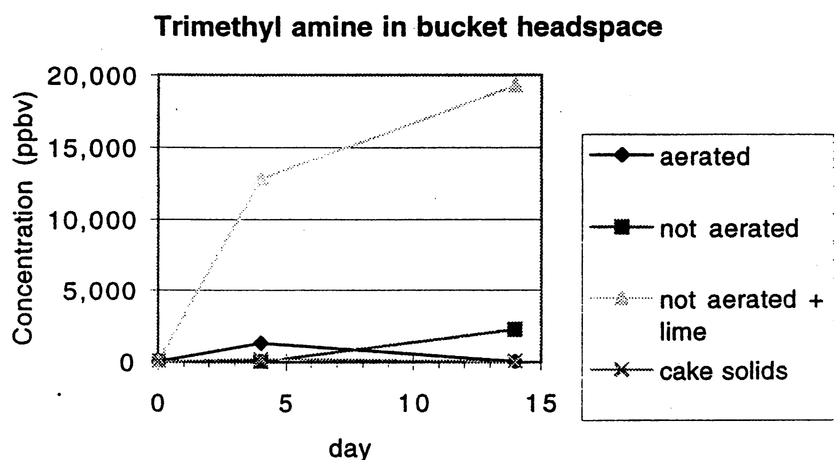
Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis			
TIC DATA																					
Decane(CAS#124-18-5)							248	J2			ppbv						220	J2			ppbv
Decane, 2,2,8-trimethyl-(CAS#62238-01-1)																					
Decane, 2,2,9-trimethyl-(CAS#62238-00-0)																	68	J2			ppbv
Decane, 2,2-dimethyl-(CAS#17302-37-3)																					
Decane, 2,5,6-trimethyl-(CAS#62108-23-0)																	175	J2			ppbv
Decane, 3,3,4-trimethyl-(CAS#49622-18-6)																	46	J2			ppbv
Decane, 3-methyl-(CAS#13151-34-3)																					
Diisooctyl Sulfate(CAS#0-00-0)																					
Dimethyl sulfide(CAS#75-18-3)	0.98	3	J2			ppbv	103000	J2			ppbv	485	J2			ppbv	56	J2			ppbv
Dimethyl-3,5 Heptene-3(CAS#0-00-0)																	98	J2			ppbv
Disiloxane, hexamethyl-(CAS#107-46-0)							246	J2			ppbv	5300	J2			ppbv					
Disulfide, dimethyl(CAS#624-92-0)	0.026	6	J2			ppbv	2660	J2			ppbv	1180	J2			ppbv					
dl-Limonene(CAS#138-86-3)																	93	J2			ppbv
Dodecane(CAS#112-40-3)																					
Ethanethioic acid, S-methyl ester(CAS#1534-08-3)							167	J2			ppbv										
Ethanethiol(CAS#75-08-1)	0.0128						4340	J2			ppbv						40	J2			ppbv
Ethanol(CAS#64-17-5)												1350	J2			ppbv					
Ether, heptyl hexyl(CAS#7289-40-9)																					
Ethyl Acetate(CAS#141-78-6)																					
Furan, 2-methyl-(CAS#534-22-5)							2270	J2			ppbv						52	J2			ppbv
Furan, 3-methyl-(CAS#930-27-8)																					
Heptane(CAS#142-82-5)							137	J2			ppbv	915	J2			ppbv	57	J2			ppbv
Heptane, 2,2,4,6,6-pentamethyl-(CAS#13475-82-6)							226	J2			ppbv						46	J2			ppbv
Heptane, 2,2-dimethyl-(CAS#1071-26-7)							179	J2			ppbv										
Heptane, 2,3-dimethyl-(CAS#3074-71-3)																					
Heptane, 2,4-dimethyl-(CAS#2213-23-2)												285	J2			ppbv					
Heptane, 2,5-dimethyl-(CAS#2216-30-0)												505	J2			ppbv	65	J2			ppbv
Heptane, 2-methyl-(CAS#592-27-8)							108	J2			ppbv						106	J2			ppbv
Heptane, 3-ethyl-2-methyl-(CAS#14676-29-0)																	49	J2			ppbv
Heptane, 3-methyl-(CAS#589-81-1)												1440	J2			ppbv	128	J2			ppbv
Heptane, 4-ethyl-2,2,6,6-tetramethy(CAS#62108-31-0)																					
Hexane(CAS#110-54-3)							928	J2			ppbv	277	J2			ppbv	54	J2			ppbv
Hexane, 2,2,4-trimethyl-(CAS#16747-26-5)												240	J2			ppbv					
Hexane, 2,2,5,5-tetramethyl-(CAS#1071-81-4)																					
Hexane, 2,2,5-trimethyl-(CAS#3522-94-9)							206	J2			ppbv	147	J2			ppbv	94	J2			ppbv
Hexane, 2,3,4-trimethyl-(CAS#921-47-1)																					
Hexane, 2,3-dimethyl-(CAS#584-94-1)												395	J2			ppbv					
Hexane, 2,4-dimethyl-(CAS#589-43-5)												1000	J2			ppbv	60	J2			ppbv
Hexane, 2,5-dimethyl-(CAS#592-13-2)												2170	J2			ppbv					
Hexane, 2-methyl-(CAS#591-76-4)												796	J2			ppbv					
Hexane, 3,3-dimethyl-(CAS#563-16-6)												254	J2			ppbv					
Hexane, 3,4-dimethyl-(CAS#583-48-2)												144	J2			ppbv					
Hexane, 3-ethyl-2-methyl-(CAS#16789-46-1)												156	J2			ppbv					
Hexane, 3-methyl-(CAS#589-34-4)												574	J2			ppbv					
Hexanoic acid, 3-hexenyl ester, (Z)(CAS#31501-11-8)																	63	J3			ppbv
Isobutane(CAS#75-28-5)							2220	J2			ppbv	301	J2			ppbv					
Isooctane (CAS#26635-64-3)																	100	J2			ppbv
Isopropyl Alcohol(CAS#67-63-0)							18200	J2			ppbv						88	J2			ppbv
Limonene(CAS#138-86-3)																					

8/3 bucket test gas sample - TIC-tentatively IDed compounds

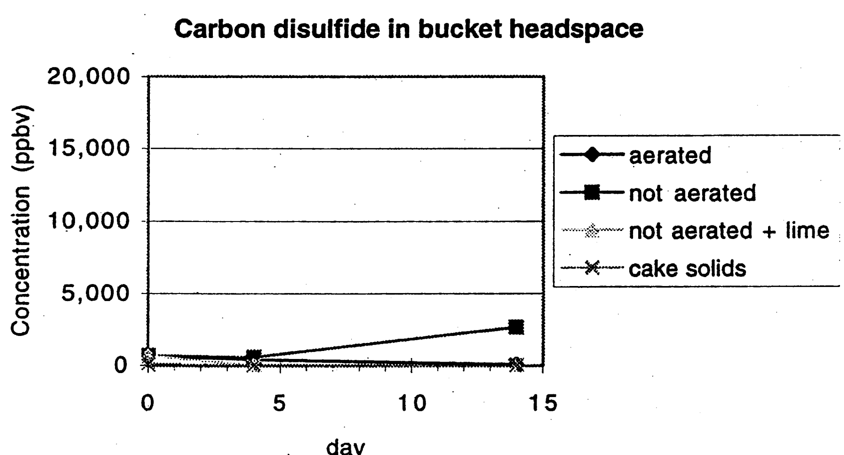
PROJECT: 423163-49

	Sample 1	Sample 2	Sample 3	Sample 4
Locator:	NONE	NONE	NONE	NONE
Descrip:	Centridry product aerated	Centridry product unaerate	Centridry + lime	Renton cake solids
Client Loc:	T=15 days	T=15 days	T=15 days	T=15 days
Sampled:	Aug 17, 1999	Aug 17, 1999	Aug 17, 1999	Aug 17, 1999
Lab ID:	L16212-1	L16212-2	L16212-3	L16212-4
Matrix:	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR	AMBIENTAIR
% Solids:				

Parameters	Detection Threshold	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
			-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis					-Wet Weight Basis			
TIC DATA																					
Methallylcyclohexane(CAS#0-00-0)																					
Methanethiol(CAS#74-93-1)	0.021						218000	J2			ppbv						156	J2			ppbv
Naphthalene, decahydro-, trans-(CAS#493-02-7)																					
Nonane(CAS#111-84-2)												199	J2			ppbv	152	J2			ppbv
Nonane, 3-methyl-(CAS#5911-04-6)							100	J2			ppbv						203	J2			ppbv
Nonane, 3-methyl-5-propyl-(CAS#31081-18-2)							224	J2			ppbv						135	J2			ppbv
Nonane, 4-methyl-5-propyl-(CAS#62185-55-1)																					
Nonane, 5-methyl-(CAS#15869-85-9)																					
Octane(CAS#111-65-9)							440	J2			ppbv	1590	J2			ppbv	452	J2			ppbv
Octane, 2,6-dimethyl-(CAS#2051-30-1)																					
Octane, 2-methyl-(CAS#3221-61-2)												555	J2			ppbv					
Octane, 3-methyl-(CAS#2216-33-3)												322	J2			ppbv	73	J2			ppbv
Octane, 4,5-dimethyl-(CAS#15869-96-2)																					
Octane, 4-methyl-(CAS#2216-34-4)																	83	J2			ppbv
Pentane(CAS#109-66-0)												237	J2			ppbv	41	J2			ppbv
Pentane, 2,2,4-trimethyl-(CAS#540-84-1)																					
Pentane, 2,3,4-trimethyl-(CAS#565-75-3)												571	J2			ppbv					
Pentane, 2,3-dimethyl-(CAS#565-59-3)												216	J2			ppbv					
Pentane, 3,3-dimethyl-(CAS#562-49-2)																					
Pentane, 3-methyl-(CAS#96-14-0)												166	J2			ppbv					
Propanal, 2-methyl-(CAS#78-84-2)		51	J2			ppbv															
Propanal, 2-propenylhydrazone(CAS#19031-78-8)																					
Propane, 2-methyl-(CAS#75-28-5)																					
Propene(CAS#115-07-1)							13500	J2			ppbv						565	J2			ppbv
Pyridine(CAS#110-86-1)																					
Silanol, trimethyl-(CAS#1066-40-6)		12	J2			ppbv	3290	J2			ppbv	7180	J2			ppbv	53	J2			ppbv
Sulfide, allyl methyl(CAS#10152-76-8)												424	J2			ppbv					
Thiirane, methyl-(CAS#1072-43-1)							1510	J2			ppbv										
Trans Nonene-3(CAS#0-00-0)																					
Tridecane, 3-methylene-(CAS#19780-34-8)																					
Trimethylamine(CAS#75-50-3)	0.046						22300	J2			ppbv	19300	J2			ppbv					
Trisulfide, dimethyl(CAS#3658-80-8)	1.220						650	J2			ppbv										
Undecane(CAS#1120-21-4)																					
Undecane, 2,8-dimethyl-(CAS#17301-25-6)																					
Unknown(CAS#74685-31-7)																					
Unknown(CAS#SCAN#)																					



Note: y-axes are not the same



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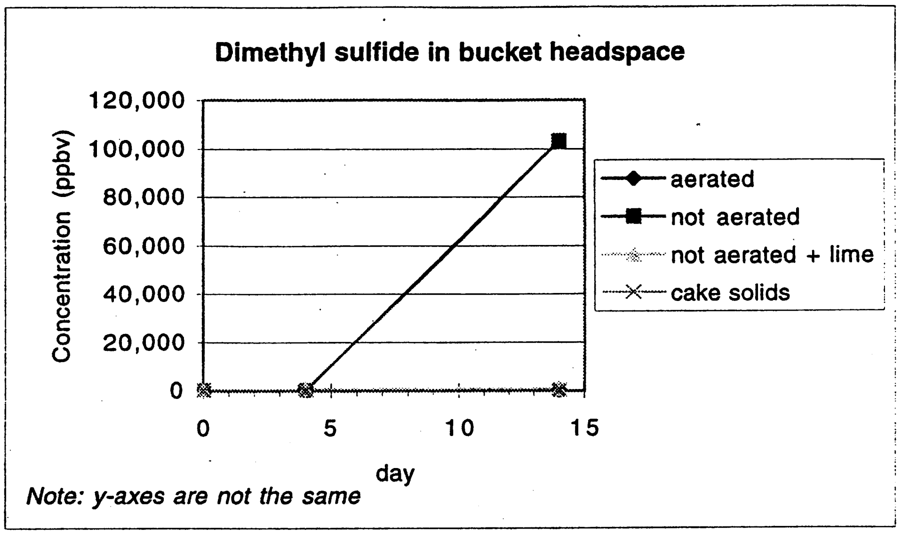
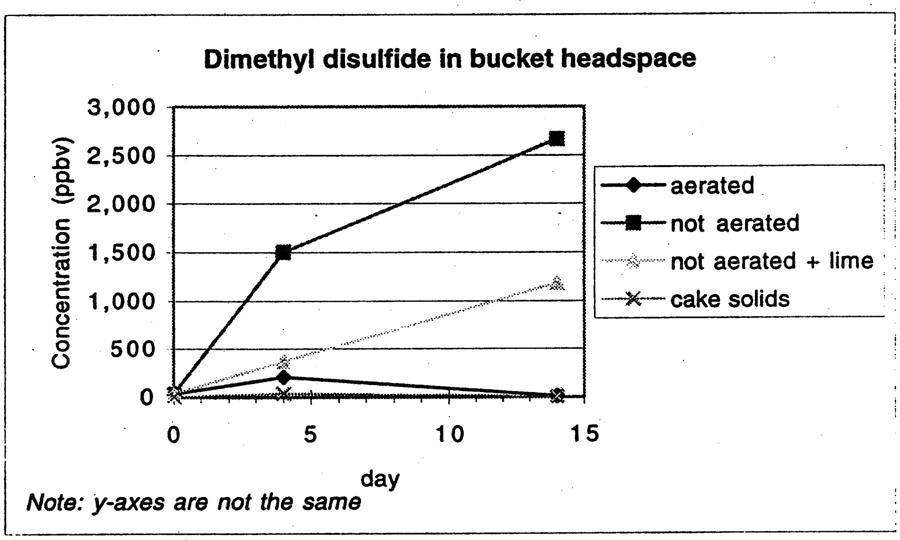
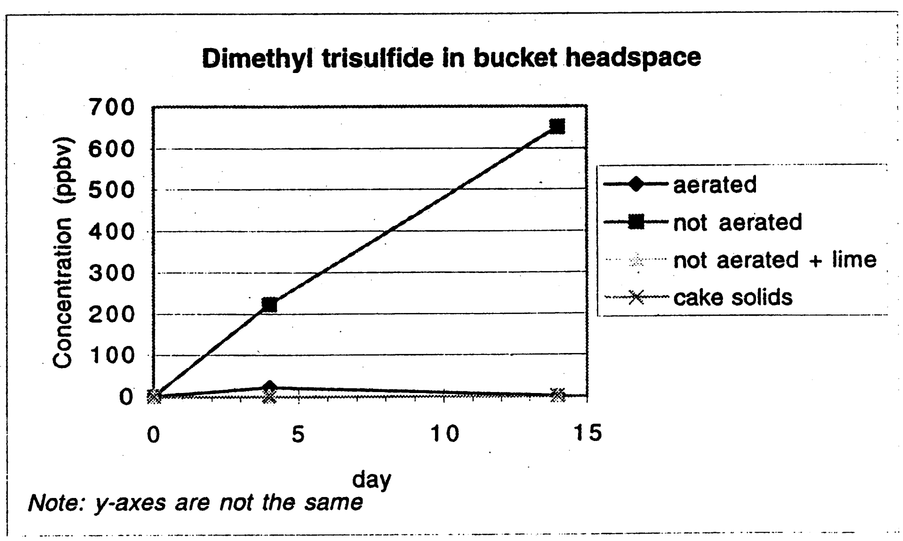
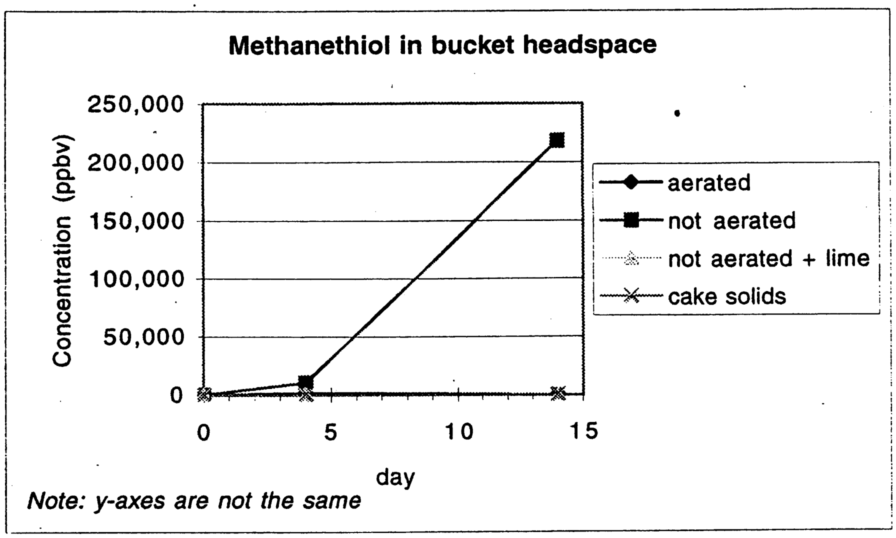
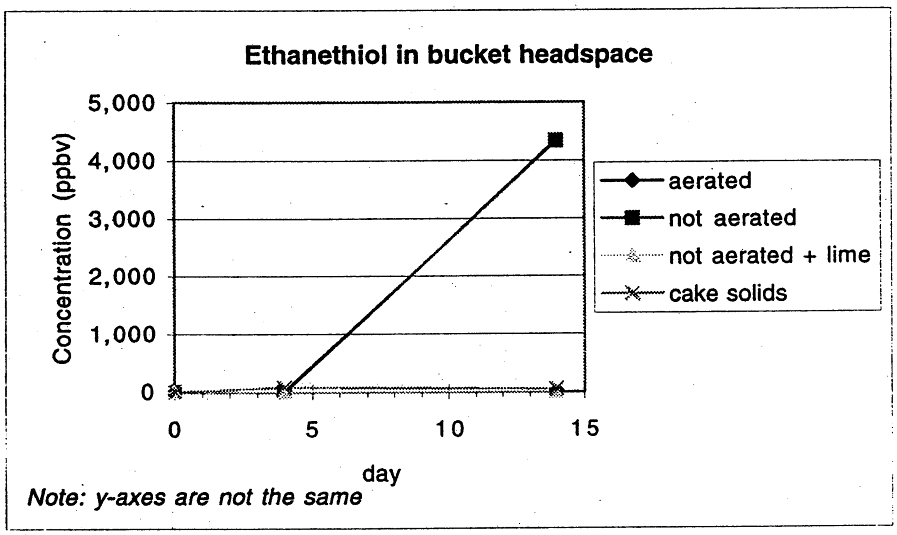

Dimethyl sulfide in bucket headspace
Concentration (ppbv)
120,000
100,000
80,000
60,000
40,000
20,000
0
0
5
10
15
day
aerated
not aerated
not aerated + lime
cake solids
Note: y-axes are not the same


Dimethyl disulfide in bucket headspace
Concentration (ppbv)
3,000
2,500
2,000
1,500
1,000
500
0
0
5
10
15
day
aerated
not aerated
not aerated + lime
cake solids
Note: y-axes are not the same

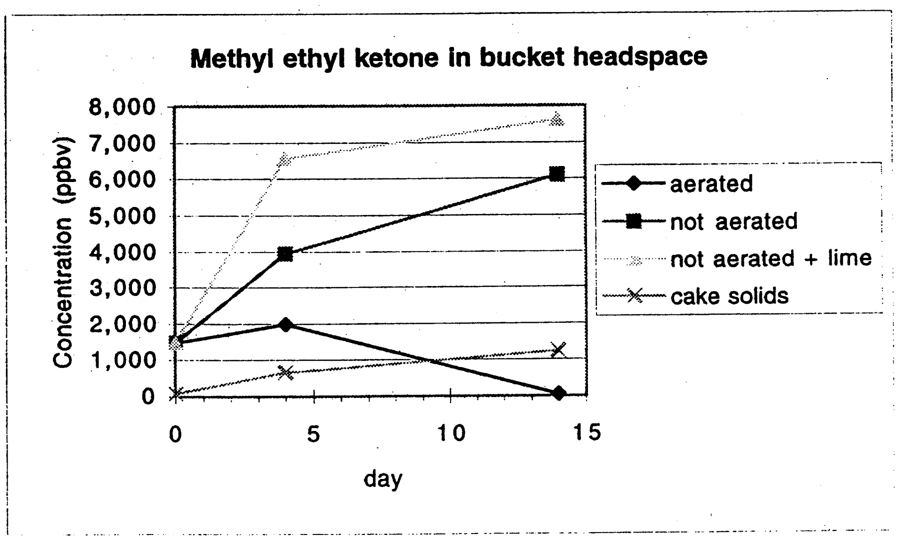

Dimethyl trisulfide in bucket headspace
Concentration (ppbv)
700
600
500
400
300
200
100
0
0
5
10
15
day
aerated
not aerated
not aerated + lime
cake solids
Note: y-axes are not the same



Methanethiol in bucket headspace
250,000
200,000
150,000
100,000
50,000
0
Concentration (ppbv)
0
5
10
15
day
aerated
not aerated
not aerated + lime
cake solids
Note: y-axes are not the same



Ethanethiol in bucket headspace
5,000
4,000
3,000
2,000
1,000
0
Concentration (ppbv)
0
5
10
15
day
aerated
not aerated
not aerated + lime
cake solids
Note: y-axes are not the same



Methyl ethyl ketone in bucket headspace
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Concentration (ppbv)
0
5
10
15
day
aerated
not aerated
not aerated + lime
cake solids

8/3 odor panel - day0

Sample 1: Cake solids day 0 [3 Aug 99]									
Dilution gas rate	5000	5000	5000	5000	5000	5000	5000	5000	
Odorous Gas rate	200	120	270	120	205	205	240	205	
Panelist	Dilutions to Threshold								log 10
Greg Moen	25 musty, sewer								1.40
Margaret Hahn	42 cabbage, resinous, vomit, woody, yeasty, sour								1.62
Paul Kawamoto	19 burnt wood								1.27
Patrick Clark	42 decayed, wet dog, salty, sewer, putrid								1.62
Chad Newton	24 earthy, wet dog								1.39
Jaana Pietari	24 malty								1.39
Pardi Jitnuyanot	21 malty, mushroom-like								1.32
Amy Groome	24 bark, smoky								1.39
	D/T50 geometric mean								26.5
	std log deviation								0.129
Sample 2: Centridry not aerated day 0 [3 Aug 99]									
Dilution gas rate	5000	5000	5000	5000	5000	5000	5000	5000	
Odorous Gas rate	140	140	140	140	140	140	140	140	
Panelist	Dilutions to Threshold								log 10
Greg Moen	36 musty, fruity, chocolate								1.55
Margaret Hahn	36 fruity, minty, wet wood								1.55
Paul Kawamoto	36 sour milk								1.55
Patrick Clark	36 chocolate, sour milk, malty								1.55
Chad Newton	36 chocolate, sweaty, chocolate milk								1.55
Jaana Pietari	36 malty								1.55
Pardi Jitnuyanot	36 wet paper, earthy								1.55
Amy Groome	36 bark, chocolate, earthy, smoky								1.55
	D/T50 geometric mean								35.71
	std log deviation								0
Sample 3: Centridry aerated day 0 [3 Aug 99]									
Dilution gas rate	5000	5000	5000	5000	5000	5000	5000	5000	
Odorous Gas rate	120	120	140	120	130	130	130	130	
Panelist	Dilutions to Threshold								log 10
Greg Moen	42 musty, chocolate								1.62
Margaret Hahn	42 manure, mushroom-like, salty								1.62
Paul Kawamoto	36 sour milk								1.55
Patrick Clark	42 garbage dump								1.62
Chad Newton	38 wet dog, resinous, sweaty, earthy								1.59
Jaana Pietari	38 greasy								1.59
Pardi Jitnuyanot	38 rotten fruit								1.59
Amy Groome	38 earthy, wet dog								1.59
	D/T50 geometric mean								39.27
	std log deviation								0.024
Sample 4: Centridry + Lime day 0 [3 Aug 99]									
Dilution gas rate	5000	5000	5000	5000	5000	5000	5000	5000	
Odorous Gas rate	120	120	120	120	130	130	130	130	
Panelist	Dilutions to Threshold								log 10
Greg Moen	41.7 musty, chocolate								1.62
Margaret Hahn	41.7 fish fertilizer, rubbery								1.62
Paul Kawamoto	41.7 vinegar								1.62
Patrick Clark	41.7 rotten egg								1.62
Chad Newton	38.5 wet dog								1.59
Jaana Pietari	38.5 ammonia								1.59
Pardi Jitnuyanot	38.5 ammonia, cadaverous								1.59
Amy Groome	38.5 ammonia, pungent								1.59
	D/T50 geometric mean								40.03
	std log deviation								0.019

8/3 odor panel - day 3

Sample 1: Cake solids day 3 [6 Aug 99]								
Dilution gas rate	5000		5000		10000	5000	5000	10000	
Odorous Gas rate	30		50		120	30	50	120	
Panelist	Dilutions to Threshold								log 10
Greg Moen	167 musty, sour milk, grass								2.22
Margaret Hahn									
Paul Kawamoto	100 burnt wood, musty								2.00
Patrick Clark									
Chad Newton	83 earthy, pungent, salty, smoky, sweaty								1.92
Jaana Pietari	167 wet wool, woody								2.22
Pardi Jitnuyanot	100 rotten fruit, rubbery								2.00
Amy Groome	83 almond, smoky, sour milk, wood smoke								1.92
					D/T50 geometric mean				111.6
					std log deviation				0.14

Sample 2: Centridry not aerated day 3 [6 Aug 99]									
Dilution gas rate	5000		5000		10000	5000	5000	10000	
Odorous Gas rate	50		70		75	50	70	75	
Panelist	Dilutions to Threshold								log 10
Greg Moen	100 rotten cabbage,sour milk, yeasty								2.00
Margaret Hahn									
Paul Kawamoto	71 decayed wood,								1.85
Patrick Clark									
Chad Newton	133 earthy, musty, sour milk								2.12
Jaana Pietari	100 cabbage, malty								2.00
Pardi Jitnuyanot	71 pungent, rotten cabbage, rotten fruit								1.85
Amy Groome	133 ammonia, burnt wood, rubbery, sour milk, wet dog								2.12
					D/T50 geometric mean				98.39
					std log deviation				0.121

Sample 3: Centridry aerated day 3 [6 Aug 99]									
Dilution gas rate	5000		5000		10000	5000	5000	10000	
Odorous Gas rate	50		120		120	50	120	120	
Panelist	Dilutions to Threshold								log 10
Greg Moen	100 earthy, musty								2.00
Margaret Hahn									
Paul Kawamoto	42 fish, putrid								1.62
Patrick Clark									
Chad Newton	83 earthy, salty, sweaty								1.92
Jaana Pietari	100 ammonia, fish fertilizer, rancid								2.00
Pardi Jitnuyanot	42 cadaverous, malty, pungent								1.62
Amy Groome	83 chocolate, salty, smoky, woody								1.92
					D/T50 geometric mean				70.29
					std log deviation				0.179

Sample 4: Centridry + Lime day 3 [6 Aug 99]									
Dilution gas rate	5000		5000		10000	5000	5000	10000	
Odorous Gas rate	50		100		100	50	50	100	
Panelist	Dilutions to Threshold								log 10
Greg Moen	100 earthy, fish, manure, musty								2.00
Margaret Hahn									
Paul Kawamoto	50 ammonia								1.70
Patrick Clark									
Chad Newton	100 ammonia, earthy, musty, pungent								2.00
Jaana Pietari	100 ammonia, fish fertilizer								2.00
Pardi Jitnuyanot	100 ammonia, cadaverous, fish fertilizer								2.00
Amy Groome	100 ammonia, sour milk								2.00
					D/T50 geometric mean				89.09
					std log deviation				0.123

8/3 odor panel - day 14

Sample 1: Cake solids day 14 [17 Aug 99]									
Dilution gas rate	10000	10000	10000	10000	10000	10000	10000	10000	
Odorous Gas rate	100	100	100	100	50	70	70	100	
Panelist	Dilutions to Threshold								log 10
Greg Moen	100 earthy, musty								2.00
Margaret Hahn	100 natural gas								2.00
Paul Kawamoto	100 decayed, musty								2.00
Patrick Clark	100 putrid, rotten egg, sour milk								2.00
Chad Newton	200 earthy, salty, sweaty								2.30
Jaana Pietari	143 putrid, rancid								2.15
Pardi Jitnuyanot	143 ammonia, decayed								2.15
Amy Groome	100 burnt rubber, earthy, pungent, sour milk								2.00
					D/T50 geometric mean				119.2
					std log deviation				0.115

Sample 2: Centridry not aerated day 14 [17 Aug 99]									
Dilution gas rate	10000	10000	10000	10000	10000	10000	10000	10000	
Odorous Gas rate	130	120	130	120	120	130	130	120	
Panelist	Dilutions to Threshold								log 10
Greg Moen	77 sour milk								1.89
Margaret Hahn	83 fruity, sour milk								1.92
Paul Kawamoto	77 rotten egg								1.89
Patrick Clark	83 putrid, rotten egg, sour milk, wet dog								1.92
Chad Newton	83 earthy, pungent, resinous, sour milk								1.92
Jaana Pietari	77 rotten cabbage, rotten egg								1.89
Pardi Jitnuyanot	77 rotten egg, rotten fruit								1.89
Amy Groome	83 almond, smoky, sweaty, wet dog								1.92
					D/T50 geometric mean				80.06
					std log deviation				0.019

Sample 3: Centridry aerated day 14 [17 Aug 99]									
Dilution gas rate	10000	10000	10000	10000	10000	10000	10000	10000	
Odorous Gas rate	160	140	160	140	140	160	160	140	
Panelist	Dilutions to Threshold								log 10
Greg Moen	63 decayed, musty								1.80
Margaret Hahn	71 chocolate, sour milk								1.85
Paul Kawamoto	63 decayed, musty								1.80
Patrick Clark	71 manure, putrid, sewer								1.85
Chad Newton	71 earthy, sour milk								1.85
Jaana Pietari	63 fish, rancid								1.80
Pardi Jitnuyanot	63 decayed, rotten cabbage								1.80
Amy Groome	71 chocolate, smoky, wet dog								1.85
					D/T50 geometric mean				66.82
					std log deviation				0.031

Sample 4: Centridry + Lime day 14 [17 Aug 99]									
Dilution gas rate	10000	10000	10000	10000	10000	10000	10000	10000	
Odorous Gas rate	80	90	80	100	100	80	80	100	
Panelist	Dilutions to Threshold								log 10
Greg Moen	125 earthy, musty								2.10
Margaret Hahn	111 fish fertilizer, rubbery								2.05
Paul Kawamoto	125 decayed, musty								2.10
Patrick Clark	100 putrid, rotten egg, sour milk, wet dog								2.00
Chad Newton	100 earthy, fish, salty, sour milk, sweaty								2.00
Jaana Pietari	125 putrid, rancid								2.10
Pardi Jitnuyanot	125 decayed, fish								2.10
Amy Groome	100 decayed, earthy, manure, salty, sour milk, sweaty								2.00
					D/T50 geometric mean				113.3
					std log deviation				0.048

TAB

E

APPENDIX E

PRODUCT MODIFICATION AND ODOR CHARACTERIZATION TESTS (MAY 2000)

Data Sources:

- General Overview
- Product Odor Characterization and Control
- Microbiological and Gas Sample Results from King County Environmental Laboratory

General Overview

The Centridry Demonstration Project evaluated the potential for implementation of the biosolids drying process at King County wastewater treatment facilities. Results from the evaluation indicate that the process can produce dewatered biosolids at 50 - 60% solids content in a mechanically reliable and operator-friendly manner. Although the product is substantially different from the currently produced 15 - 25% solids dewatered cake, the results of the investigation indicate that there is significant potential for beneficial reuse of Centridry product. The product is highly amenable to composting to a Class A biosolid and is potentially suitable for land application. However, there are significant issues regarding the characteristics and acceptability of the Centridry product which must be resolved in order to thoroughly evaluate the feasibility of full-scale implementation.

In 1998, Centridry product was distributed to several potential end-users for evaluation of the suitability to the various applications. These included composting and direct application at forestry and agricultural sites. The primary concerns with the product were odors from fresh and composted material, handling issues (dust), and health safety. The tasks outlined in this project will address these issues to further evaluate the feasibility of full-scale implementation.

The work in this project is divided into five tasks. Task one will consist of characterization of product odors by chemical analysis and odor panel evaluations, identification of potential causes and control measures, and bench-scale testing to screen potential causes and control measures. Task two addresses the use of a biofilter to control product composting odors, and includes characterizing the product odors during and after composting. Task three evaluates the characteristics of composted Centridry product, including odor and potential for dust formation. This task will also examine the interest of new markets such as soil manufacturers in the composted Centridry product. Task four examines the microbiological characteristics of Centridry product and composted product, including the potential for recovery and regrowth of Salmonella and fecal coliforms. Task five evaluates the potential to suppress dust formation by mixing Centridry product and cake solids from the belt filter presses at the South Treatment Plant to produce a material of higher moisture content than Centridry product alone.

PRODUCT ODOR CHARACTERIZATION AND CONTROL

1. GOALS

Identify causes and potential methods for control of objectionable odors of fresh and aged Centridry product.

- Characterize odors from fresh and aged Centridry product, and compare with cake solids from belt filter presses.
- Test hypothesized odor causes through product aging tests, gas chromatographic odor analysis and odor panel evaluation.
- Determine specific compounds responsible for objectionable odors, and quantify differences between Centridry™ product and cake solids.

2. METHODOLOGY

The Centridry Demonstration Project revealed that the Centridry product has a tendency to produce objectionable odors when stored in a trailer or bin for several days. Additionally, biosolids users at forest, wheat and hop field sites commented that the odors of the fresh product were "sharp", " terrible", or "offensive". In order to evaluate the potential for an acceptable end-use for Centridry product, a method must be developed for controlling odors from stored material. This research will 1) characterize the objectionable odors and determine differences from the odors of cake solids, 2) investigate the causes of the odor generation, and 3) test methods of limiting the objectionable odors.

Due to its dryness, the Centridry product is a substantially different material from the cake solids currently produced. Comments from operators have indicated dissatisfaction with dust and lingering odors. Maintaining solids contents below 60% has been shown to control dust. Unfortunately, the dryness of the product makes it highly amenable to volatilization of the myriad of organic compounds in biosolids. The liquid boundary layer is greatly reduced. A model of the product structure that has been proposed and will be tested by this research is that biosolids particles (avg. d_{50} ~1 mm) leave the centrifuge and are flash dried, which makes them dry on the outside and moist on the inside. Thus, biological activity can flourish in the interior while odorous compounds produced are readily off-gassed, providing a near-perfect micro-environment for production and volatilization of odorous compounds.

This research will provide a basis for developing a method to control odors from stored product. The following questions will be addressed:

- What compounds are responsible for the objectionable odors? How does the odor character change with time?

- How is the odor different from the odor of cake solids?

- Is the odor from aging Centridry product the result of microbial activity?

- If so, is it possible to select for a microbial population that does not produce objectionable odors?

Odor Characterization

The unique nature of the Centridry product and associated odor requires that a characterization of the odor be completed to support efforts to identify causes and control measures. Two previous Centridry™ product aging tests were conducted in 5 gallon buckets, and the off-gas analyzed by gas chromatography to identify and quantify odorous compounds with the goal of identifying the primary compounds responsible for the unpleasant odor of Centridry product. Product off-gas samples were also evaluated by an informal odor panel to evaluate odor strength (dilution to threshold testing) and composition (comparison to standards, informal evaluations). These analyses were done in parallel to correlate measured differences in gas composition with differences in panelist's perception of odor character. (For details of these tests, please see the June 1999 version of this test plan.) The results of the characterization study were summarized by Technology Assessment and Resource Recovery (TARR) staff in a technical memorandum (Centridry™ Product Evaluation Workshop Handout). The memorandum includes qualitative and quantitative data from the chemical composition analysis and odor panel evaluations, and preliminary conclusions regarding methods to mitigate odors. These data were evaluated by a panel of experts provided by the consultant, and the purpose of this test is to conduct further Centridry™ product evaluation based on their recommendations.

Testing Summary

The testing will consist of storing Centridry product in flux chambers under various conditions and comparing the odor character and microbial population dynamics over a time course of about two weeks. There will be five test conditions:

1. Centridry product stored with anaerobic headspace; (intended to simulate storage conditions;)
2. Centridry product sterilized by gamma-irradiation stored with anaerobic headspace;
3. Centridry product stored with aerobic headspace; (exogenous electron acceptor)
4. Centridry product mixed with cake solids; (reinoculation of microorganisms)
5. Cake solids with anaerobic headspace;

A primary challenge of this work will be to establish conditions at bench-scale similar to in-situ storage conditions in order to generate the odors that are observed at full-scale (test condition 1). Comparing changes in gas phase concentration of odorous compounds (GC analysis) to changes in odor intensity (odor panel) during the timecourse should provide some indication of the compounds associated with the objectionable odors. The various treatments will test hypotheses concerning the causes of the odor generation and potential methods of controlling odor generation such as adding an exogenous electron acceptor (e.g., O_2) or inoculating with a source of microorganisms (cake solids).

Tests will be conducted in flux chambers (described below) stored in a water bath at 60 °C . Anaerobic chambers will be flushed with nitrogen; aerobic chambers flushed with oxygen. Gas samples will be analyzed by gas chromatography to identify and quantify potential odorous compounds; odor panel analysis will indicate odor intensity and human perception of the odor. Solids samples will be analyzed for conventional parameters; microbial populations will be characterized by estimating the fractions of anaerobic, aerobic and spore-forming microbes.

Hypotheses

The research will test the following hypotheses:

Hypothesis 1: The objectionable odors when Centridry product is stored for several days is due to biological activity; i.e., the odors are not attributable solely to physical/chemical processes.

Test: Off-gas characteristics (odor intensity, chemical constituents) of sterilized product (gamma irradiation) will be compared to unsterilized product; both treatments will be stored under anaerobic conditions.

Interpretation: Higher levels of objectionable odors from the unsterilized product compared to the sterilized product would indicate that microorganisms contribute to odor generation. Similar odor levels between the treatments would indicate that odor emissions are attributable to the chemical and physical nature of the Centridry product.

Hypothesis 2: The objectionable odors when Centridry product is stored for several days is due to a lack of suitable electron acceptors (O_2, NO_3), allowing anaerobic and fermentative metabolism to occur. The products of anaerobic and fermentative metabolism are generally more odorous than those of aerobic respiration.

Tests: Off-gas characteristics of product stored under anaerobic conditions will be compared to product stored in an oxygen-rich environment. Plate counts of aerobic, anaerobic and spore-forming bacteria will be conducted to characterize the microbial populations.

Interpretation: Lower levels of objectionable odors from the product stored under aerobic conditions would indicate that anaerobic and fermentative activity is responsible for odor generation. Bacterial counts should confirm this difference in microbial populations.

Hypothesis 3: The Centridry process selects for an odor-producing microbial population by inactivating populations that would normally compete with them.

Tests: Plate counts of aerobic, anaerobic and spore-forming bacteria will be conducted on feed to the Centridry process and the product. Off-gas characteristics of product mixed with cake solids from the South Treatment Plant dewatering process will be compared to unamended Centridry product; both treatments will be stored with an anaerobic headspace. Plate counts of aerobic, anaerobic and spore-forming bacteria in the mixed and unamended treatments will be conducted to characterize the microbial populations.

Interpretation: Changes in the microbial population distribution from the Centridry feedstock to the product, particularly the fraction of spore-formers, would indicate microbial population selection by the Centridry process. Lower levels of objectionable odors from the product inoculated with cake solids would also indicate that odor production is attributable to selection for an odor-producing microbial population by the

Centridry drying process. Bacterial counts in mixed and unamended product should confirm differences in microbial population distribution.

3. EXPERIMENTAL SETUP, SAMPLING AND ANALYSIS

Equipment

Solids will be stored in flux chambers (5 gallon buckets) equipped with gas inlet and outlet ports and solids sampling ports inserted through the lid. The gas inlet will extend to a distribution manifold in the bottom of the chamber; outlet port will be at the top of the chamber. Solids sampling port will be a 2" threaded port with cap. There will be no insertions through the sidewalls of the chamber. Chambers will be stored in a water bath at 60 °C to simulate the heat generated by Centridry product stored in piles.

Flux chamber preparation

Biosolids will be weighed prior to addition to flux chambers; chambers will contain equal amounts of material on a dry weight basis. Biosolids will occupy approximately 40% of the chamber volume.

The following specifications for treatment preparations are estimated assuming 60% TS Centridry product and 18% cake solids. Weights will be adjusted based on actual conditions.

Test conditions 1: Centridry product w/ anaerobic headspace
Centridry product: 9.4 lbs.
TS%: 60%
Seal material in flux chamber ; flush headspace with nitrogen (see procedure below).

Test condition 2: sterilized Centridry product w/ anaerobic headspace
Centridry product: 9.4 lbs.
TS%: 60%
Seal material in small containers for gamma irradiation; transfer irradiated material to sterilized flux chamber (rinsed with chlorine solution); flush headspace with N_2.

Test condition 3: Centridry product w/ aerobic headspace
Centridry product: 9.4 lbs.
TS%: 60%
Add water via spray bottle, mix thoroughly; seal material in flux chamber ; flush headspace with oxygen.

Test condition 4: Centridry product mixed with cake solids (4:1, dry) w/ anaerobic headspace
Centridry product: 7.52 lbs.
Filter press cake: 6.27 lbs.
Final TS%: 41%
Mix Centridry into cake solids; seal material in flux chamber; flush headspace with N_2.

Test condition 5: Cake solids w/ anaerobic headspace

Belt press cake solids:
TS%:
Seal material in flux chamber; flush headspace with N_2.

Headspace flushing

The chamber headspace will be flushed with N_2 or O_2 by pumping known volumes of gas from a Tedlar bag via a peristaltic pump (equipped with a continuous length of 3/8" Norprene hose) into the bottom of the chamber. There will be no inlet for ambient air. Headspace gas will exit out the top of the chamber to the atmosphere. Three headspace volumes will be pumped through the chamber to establish initial conditions.

The aerobic environment of test condition 3 will be maintained by flushing with one headspace volume (12 L) of O_2 on a bi-daily basis. The buckets will be agitated (turned upside down, gently shaken) once per day to promote equilibrium between the gas and solid phases.

The anaerobic environments of test conditions 1, 2, 4 and 5 will be maintained by flushing with N_2. All of the chambers will be flushed with the same volume of gas and at the same frequency to maintain the same dilution effect in each condition.

Gas sampling

Headspace gas will be sampled into 3L Tedlar bags using the peristaltic pump. A bag containing N_2 (or O_2) in the required sample volume will be pumped into the gas inlet of the chamber. Headspace gas will be displaced into a sample bag connected to the outlet port. See Tables A.1 and A.2 in Appendix A for the detailed sampling plan.

Solids sampling

Biosolids will sampled by inserting a ladle through the threaded 2" port at the top of the chamber. Care must be used to limit the introduction of ambient air. Material will be removed from the center of the chamber. The sterilized chamber will be sampled only at the start and end of the test to prevent reinoculation during the test. See Tables A.1 and A.2 in Appendix A for the detailed sampling plan. Table A.3 contains a list of the compounds identified through GC/MS odor analysis.

Data review and further testing

At the end of this bucket test, the data will be reviewed by the expert panel provided by the consultant. Further tests may be conducted if the expert panel, consultant, or King County staff determine that the questions listed earlier in this section have not been adequately answered.

4. PARTICIPANTS AND RESPONSIBILITIES

- TARR program – Design and conduct testing, coordinate process operations, collect and distribute samples, distribute and evaluate data
- South Treatment Plant Staff - Support operations
- King County Environmental Lab – GC/MS odor analysis, product sample analysis and contract laboratory coordination, conventional analyses as needed to support

other analyses (e.g., total solids for reporting dry-weight normalized results such as bacterial enumeration)

- South Treatment Plant Process lab – Conventional analyses
- Consultant – Review test plan, data analysis, expert panel coordination
- Baker Process/Humboldt - Support operations

5. SCHEDULE

Work Item	Dates Performed	Completed
Operate Centridry™ system	5/8/00 - 5/9/00	Completed (rev 2)
Conduct flux chamber test	5/9/00 – 5/25/00	Completed (rev 2)
Analyse data with expert panel	7/1/00 – 7/19/00	
Summary report	7/31/00	

All sampling will be conducted by TARR.

6. WORK PRODUCT

The results and interpretation of the data will be summarized in a report by the TARR.

Appendix A
Task Sampling Plans

Parameters, sample frequency, method of analysis, collection responsibility, and analysis responsibility have been outlined in the following tables.

Table 1 – Feed, product and cake solids

Table 2 – Flux chamber solids and gas samples

Table 3 – Compounds identified by GC/MS odor analysis

Table A.1 - Product Odor Characterization
(Chemical and Microbiological Identification)
Process Operation and Flux Chamber Sampling Plan

Sample Locations	Parameter	Sample Frequency	Method of Analysis	Collection Responsibility	Analysis Responsibility
Feed, Product, and Cake solids (Process Op.)	Temperature	Daily	temperature probe	TARR	TARR
	Total solids	1 per day – composite	2540-B, Std Mthd, 19th ed.	TARR	Process Lab
	Volatile solids	1 per day – composite	2540-E, Std Mthd, 19th ed.	TARR	Process Lab
	pH	"	pH probe	TARR	Process Lab
	NH_3-N	"	4500-NH_3-D, Std Mthd, 19th ed.	TARR	Process Lab
	TKN	"	4500-NORG, Std Mthd, 19th ed.	TARR	Process Lab
	SO_4^{2-}	"		TARR	Environ Lab
	Total sulfur	"		TARR	Environ Lab
	Microbe counts[a]	"	Spread plates (differential counts)	TARR	Environ Lab

[a] Aerobic, anaerobic, aerobic spore formers, anaerobic spore formers

Table A.2 - Product Odor Characterization
(Chemical and Microbiological Identification)
Flux Chamber Sampling Plan

Sample Locations	Parameter	Sample Frequency	Method of Analysis	Collection Responsibility	Analysis Responsibility
Buckets	Temperature	daily	Temperature probe	TARR	TARR
	Total solids	Days 6 and 14 (except bucket 2)	2540-B, Std Mthd, 19th ed.	TARR	Process Lab
	Volatile solids	Days 6 and 14 (except bucket 2)	2540-E, Std Mthd, 19th ed.	TARR	Process Lab
	pH	Days 6 and 14 (except bucket 2)	pH probe	TARR	Process lab
	NH_3-N	days 6 and 14 (except bucket 2)	4500-NH_3-D, Std Mthd, 19th ed.		Process lab
	TKN	days 6 and 14 (except bucket 2)	4500-NORG, Std Mthd, 19th ed.	TARR	Process lab
	SO_4^{2-}	Day 14		TARR	
	Total sulfur	Day 14		TARR	
	Microbe counts[A]	Day 9 (except bucket 2) Day 14	Spread plates (differential counts)	TARR	Environ Lab
Gas in buckets: Contained Capture And Flux Chamber	ammonia	Day 1, 7, 13, 17	Sensidyne tube	TARR	Environ Lab
	Organics[b]	Day 1, 7, 13, 17	GC/MS	TARR	Environ Lab
	TICs[b]	Day 1, 7, 13, 17	GC/MS	TARR	Environ Lab
	Odor Panel	Days 1, 13	Dilution to threshold	TARR	OS&E

[a] Aerobic, anaerobic, aerobic spore formers, anaerobic spore formers
[b] Compounds identified by GC/MS listed on Table A.3

Table A.3 - Product Odor Characterization (Chemical and Microbiological Identification: Compounds Identified by GC/MS odor analysis)

Organics		TICs		
1,1,1-Trichlorethane	Carbon tetrachloride	.ALPHA.-PINENE, (-)-(CAS#80-56-8)	Cyclohexane, 1,1,3-trimethyl-(CAS#3073-66-3)	Hexane, 2,2,4-trimethyl-(CAS#16 26-5)
1,1,2,2-Tetrachloroethane	Chlorobenzene	.beta.-Pinene(CAS#127-91-3)	Cyclohexane, 1,1-dimethyl-(CAS#590-66-9)	Hexane, 2,2,5-trimethyl-(CAS#35 9)
1,1,2-Trichloroethane	Chlorodibromomethane	1,1,4-Trimethylcyclohexane(CAS#7094-27-1)	Cyclohexane, 1,2,3-trimethyl-(CAS#1678-97-3)	Hexane, 2,3-dimethyl-(CAS#584-
1,1,2-Trichloroethylene	Chloroethane	1-Butanol(CAS#71-36-3)	Cyclohexane, 1,3-dimethyl-, cis-(CAS#638-04-0)	Hexane, 2,4-dimethyl-(CAS#589-
1,1-Dichloroethane	Chloroform	1-Butene(CAS#106-98-9)	Cyclohexane, 1,4-dimethyl-(CAS#589-90-2)	Hexane, 2,5-dimethyl-(CAS#592-
1,1-Dichloroethylene	Chloromethane	1-Heptene, 5-methyl-(CAS#13151-04-7)	Cyclohexane, 1,4-dimethyl-, trans-(CAS#2207-04-7)	Hexane, 2-methyl-(CAS#591-76-
1,2,4-Trichlorobenzene	Cis-1,2-dichloroethylene	1-Propanol, 2-methyl-(CAS#78-83-1)	Cyclohexane, 1-ethyl-4-methyl-, cis(CAS#4926-78-7)	Hexane, 3,3-dimethyl-(CAS#563-
1,2,4-Trimethylbenzene	Cis-1,3-dichloropropene	1-Propene(CAS#115-07-1)	Cyclohexane, 1-methyl-4-(1-methylet(CAS#6069-98-3)	Hexane, 3,4-dimethyl-(CAS#583-
1,2-Dibromobenzene	Dichlorodifluoromethane	1-Propene, 2-methyl-(CAS#115-11-7)	Cyclohexane, ethyl-(CAS#1678-91-7)	Hexane, 3-ethyl-2-methyl-(CAS# 46-1)
1,2-Dichloroethane	Dichlorotetrafluoroethane	2-Butanethiol(CAS#513-53-1)	Cyclohexane, methyl-(CAS#108-87-2)	Hexane, 3-methyl-(CAS#589-34-
1,2-Dichloropropane	Ethylbenzene	2-Butanol(CAS#78-92-2)	Cyclopropane, 1,1-dimethyl-(CAS#1630-94-0)	Hexanoic acid, 3-hexenyl ester, (Z)(CAS#31501-11-8)
1,3,5-Trimethylbenzene	hexachlorobutadiene	2-Hexanone, 5-methyl-(CAS#110-12-3)	Cyclotrisiloxane, hexamethyl-(CAS#541-05-9)	Isobutane(CAS#75-28-5)
1,3-Dichlorobenzene	Methylene chloride	2-Hexene(CAS#592-43-8)	Decane(CAS#124-18-5)	ISOOCTANE(CAS#26635-64-3)
1,4-Dichlorobenzene	styrene	2-Pentanol(CAS#6032-29-7)	Decane, 2,2,9-trimethyl-(CAS#62238-00-0)	Isopropyl Alcohol(CAS#67-63-0)
2-Butanone (MEK)	tetrachloroethylene	2-Pentanone(CAS#107-87-9)	Decane, 2,5,6-trimethyl-(CAS#62108-23-0)	Methanethiol(CAS#74-93-1)
4-Ethyltoluene	Toluene	2-Propanethiol(CAS#75-33-2)	Decane, 3,3,4-trimethyl-(CAS#49622-18-6)	Nonane(CAS#111-84-2)
4-Methyl-2-Pentanone (MIBK)	Total xylenes	2-Propanethiol, 2-methyl-(CAS#75-66-1)	Dimethyl sulfide(CAS#75-18-3)	Nonane, 3-methyl-(CAS#5911-04
Acetone	Trans-1,2-dichloroethylene	2-Propanol(CAS#67-63-0)	DIMETHYL-3,5 HEPTENE-3(CAS#0-00-0)	Nonane, 3-methyl-5-propyl-(CAS#31081-18-2)

Table A.3 - Product Odor Characterization (Chemical and Microbiological Identification: Compounds Identified by GC/MS odor analysis)

a-Chlorotoluene	Trans-1,3-dichloropropene	2-Propen-1-ol(CAS#107-18-6)	Disiloxane, hexamethyl-(CAS#107-46-0)	Octane(CAS#111-65-9)
Benzene	Trichlorofluoromethane	3-Heptene, 4-methyl-(CAS#4485-16-9)	Disulfide, dimethyl(CAS#624-92-0)	Octane, 2-methyl-(CAS#3221-61
Bromodichloromethane	Trichlorotrifluoroethane	3-Pentanone(CAS#96-22-0)	dl-Limonene(CAS#138-86-3)	Octane, 3-methyl-(CAS#2216-33
Bromoform	Vinyl chloride	3-Phenylindole(CAS#1504-16-1)	Ethanethioic acid, S-methyl ester(CAS#1534-08-3)	Octane, 4-methyl-(CAS#2216-34
Bromomethane	Pyridine	3-PHENYLINDOLE(CAS#1504-16-1)	Ethanethiol(CAS#75-08-1)	Pentane(CAS#109-66-0)
		Acetaldehyde(CAS#75-07-0)	Ethanol(CAS#64-17-5)	Pentane, 2,3,4-trimethyl-(CAS#5 3)
		Acetonitrile(CAS#75-05-8)	Furan, 2-methyl-(CAS#534-22-5)	Pentane, 2,3-dimethyl-(CAS#565
		ANTHRACENE, 9,10-DIHYDRO-9,10-BIS(T(CAS#56272-38-9)	Heptane(CAS#142-82-5)	Pentane, 3-methyl-(CAS#96-14-(
		Benzene, 1-methyl-2-(1-methylethyl)(CAS#527-84-4)	Heptane, 2,2,4,6,6-pentamethyl-(CAS#13475-82-6)	Propanal, 2-methyl-(CAS#78-84-
		Butanal, 2-methyl-(CAS#96-17-3)	Heptane, 2,2-dimethyl-(CAS#1071-26-7)	Propene(CAS#115-07-1)
		Butanal, 3-methyl-(CAS#590-86-3)	Heptane, 2,4-dimethyl-(CAS#2213-23-2)	Silanol, trimethyl-(CAS#1066-40-
		Butane(CAS#106-97-8)	Heptane, 2,5-dimethyl-(CAS#2216-30-0)	Sulfide, allyl methyl(CAS#10152-
		Butane, 2-cyclopropyl-(CAS#5750-02-7)	Heptane, 2-methyl-(CAS#592-27-8)	Thiirane, methyl-(CAS#1072-43-
		Butanoic acid, 3-methyl-, ethyl est(CAS#108-64-5)	Heptane, 3-ethyl-2-methyl-(CAS#14676-29-0)	Trimethylamine(CAS#75-50-3)
		Carbon disulfide(CAS#75-15-0)	Heptane, 3-methyl-(CAS#589-81-1)	Trisulfide, dimethyl(CAS#3658-8
		Carbon oxide sulfide (COS)(CAS#463-58-1)	Hexane(CAS#110-54-3)	

Appendix B

Bucket Test Alternatives

Potential bucket test mixes and alternative justification have been outlined in the following table.

Table B.1 – Product Odor Characterization Potential Treatment Bucket Tests

Table B.1 - Product Odor Characterization (Task 1)
(Chemical and Microbiological Identification)
Potential Treatment Bucket Tests

Bucket	Mix and/or Treatment	Reason for Alternative
1	Aerated product	Presence of air in an attempt to maintain aerobic conditions
2	Unaerated product	Simulating conditions found in past work with product (trailer and application sites)
3	Nitrate treated	Presence of nitrate to in an attempt to maintain aerobic conditions
4	Blended with 20% dewatered belt press cake	Impact of moisture and microbiology changes
5	Enzyme treated	Effectiveness of treatment on odor production
6	Lime treated	Effectiveness of pH adjustment
7	Product innoculated with aerobic culture (WAS)	Change in microbiology
8	Product from lower temperature processing	Effect of process temperature
9	Water treated only	Control (for other tests adding water to product)
10	Gamma-irradiated sterilized	Control (limit microbiological activity)

Appendix C

Task References

Product Odors

1. Detection limits of common odorous gasses associated with wastewater treatment, biosolids, and compost
2. De-Odorase literature from All-Tech
3. *Comparison of Odor Emissions Resulting from Three Different Types of Biosolids Applied to Forest Soils*, Paul E. Rosenfeld, Charles L. Henry, and Rob B. Harrison
4. *French Technologies Reduce Odors from Industrial Facilities*, Wastewater Technology Showcase v1 n3, WEF, Fall 1998
5. Biosolids pelletizing literature

Test notes and schedule

<table>
<tr><th>Date</th><th>Test day</th><th>Actions/notes</th></tr>
<tr><td>9-May</td><td>0</td><td>Start of test. Cdry product at 65.4% TS; cake at 16.1% TS;
<table>
<tr><th></th><th>Bucket 1</th><th>Bucket 2</th><th>Bucket 3</th><th colspan="2">Bucket 4</th><th>Bucket 5</th></tr>
<tr><td></td><td></td><td></td><td></td><td>Cdry</td><td>cake</td><td></td></tr>
<tr><td>gr wet</td><td>2800</td><td>2800</td><td>2800</td><td>2240</td><td>2000</td><td>8270</td></tr>
<tr><td>% TS</td><td>65.4</td><td>65.4</td><td>65.4</td><td>65.4</td><td>16.1</td><td>16.1</td></tr>
<tr><td>gr dry</td><td>1831</td><td>1831</td><td>1831</td><td>1465</td><td>322</td><td>1331</td></tr>
<tr><td>Headspace volume</td><td>10.3</td><td>10.3</td><td>10.3</td><td>9.6</td><td></td><td>5.9</td></tr>
</table>
Solids samples to Process Lab (conventionals): Cdry-feed, Cdry product, cake;
All Buckets flushed with 30L of appropriate gas (N2 or O2);
Note: the flushing process was the same throughout the test,
i.e., all buckets were flushed with 30L on each of the dates indicated;</td></tr>
<tr><td>10-May</td><td>1</td><td>Gas samples taken (3L); buckets flushed;</td></tr>
<tr><td>11-May</td><td>2</td><td>Solids samples for microbial analysis: Centri-feed, Cdry product, cake;</td></tr>
<tr><td>12-May</td><td>3</td><td>Buckets flushed;</td></tr>
<tr><td>14-May</td><td>5</td><td>Buckets flushed;</td></tr>
<tr><td>16-May</td><td>7</td><td>Gas samples taken (3L); Solids samples (conventionals); buckets flushed;</td></tr>
<tr><td>18-May</td><td>9</td><td>Solids samples for microbes; buckets flushed</td></tr>
<tr><td>20-May</td><td>11</td><td>Buckets flushed;</td></tr>
<tr><td>23-May</td><td>14</td><td>Gas samples taken (3L); Solids samples (conventionals); buckets flushed;</td></tr>
<tr><td>25-May</td><td>16</td><td>Solids samples for microbes; buckets flushed</td></tr>
<tr><td>28-May</td><td>19</td><td>Buckets flushed;</td></tr>
<tr><td>31-May</td><td>22</td><td>Gas samples taken (3L); test end;</td></tr>
</table>

All values ppb

	Detection Threshold	Bucket 1: Cdry, anaerobic				Bucket 2: Cdry, γ-irrad, anaerobic				Bucket 3: Cdry, aerobic				Bucket 4: Cdry:cake 4:1, anaerobic				Bucket 5: cake, anaerobic			
		Day 1	Day 7	Day 14	Day 22	Day 1	Day 7	Day 14	Day 22	Day 1	Day 7	Day 14	Day 22	Day 1	Day 7	Day 14	Day 22	Day 1	Day 7	Day 14	Day 22
ORGANICS																					
1,1,1-Trichloroethane																					
1,1,2,2-Tetrachloroethane																					
1,1,2-Trichloroethane																					
1,1,2-Trichloroethylene																					
1,1-Dichloroethane																					
1,1-Dichloroethylene																					
1,2,4-Trichlorobenzene																					
1,2,4-Trimethylbenzene		55.4	52	38	36	52.6	87.4	48	33	42.8	98	22	27	71.4	115	50.6	43.6	208	202	67.8	56
1,2-Dibromoethane																					
1,2-Dichlorobenzene																					
1,2-Dichloroethane																					
1,2-Dichloropropane																					
1,3,5-Trimethylbenzene		99	59.4	41.2	30	97.8	131	68.2	46.8	74	129	27	35	134	162	71.2	59.8	400	268	86.4	71.8
1,3-Dichlorobenzene		23	71.2	50.4	76		71.6	40	33		103	23	32	28	133	54.4	56.4	121	304	98.2	93.4
1,4-Dichlorobenzene																					
2-Butanone (MEK)	737	157000	66600	112000	904	143000	84400	72200	124000	106000	179000	1150	512	58700	126000	21400	54200	21800	70600	61100	70100
4-Ethyltoluene		48.6	28	25		43.6	63	34		40.4	69.6			63.8	83.4	37		188	100	41.6	
4-Methyl-2-Pentanone (MIBK)			834	827	667					765	2210				1770	1530	1100		1210	692	778
Acetone	460	55400	19500	152000	2730	46500	24900	46800	104000	49100	124000	615	693	15500	110000	87000	140000	4530	23500	29700	28500
A-Chlorotoluene																					
Benzene		550	111	78.6	96.4	144	253	158	145	738	345	63.6	79.8	118	156	68.4	77.4	180	101	42.6	49.2
Bromodichloromethane																					
Bromoform																					
Bromomethane																					
Carbon Tetrachloride																					
Chlorobenzene																					
Chlorodibromomethane																					
Chloroethane											147		39								
Chloroform			29		33		39				63		33								
Chloromethane		86	53.4			62.6				128	262	62.8	217	28							
Cis-1,2-Dichloroethylene																		28			
Cis-1,3-Dichloropropene																					
Dichlorodifluoromethane																					
Dichlorotetrafluoroethane																					
Ethylbenzene		656	209	118	44.4	480	636	296	196	716	714	125	118	669	648	246	142	2180	618	168	121
Hexachlorobutadiene																					
Methylene Chloride				33	24			36	21			65				41.2				46.8	22
Styrene		331	141	46.8	23	62.2	55.8	20		217	174			61.6	75.8	55.4	48.2		51	24	26
Tetrachloroethylene		21		24			32	28	29	26	27		27	24	33	25	24	58.6	25	25	27
Toluene		31200	31900	14100	3120	25900	99700	66900	32800	31400	26500	11400	10500	27000	111000	30700	11500	46200	97000	19600	13400
Total Xylenes		3800	1320	789	282	3490	4410	2160	1400	3810	3880	716	707	4710	4490	1900	1130	12500	4590	1270	868
Trans-1,2-Dichloroethylene																					
Trans-1,3-Dichloropropene																					
Trichlorofluoromethane																					
Trichlorotrifluoroethane																					
Vinyl Chloride											22										
Carbon Disulfide	7.7	2960	1830	2510	3310	3740	3070	3270	1080	4270	4410	1880	2220	1130	1950	2170	2230	160	538	301	381
Carbonyl Sulfide		430	2580	3020	1500	671	3080	3950	2300	122	1420	754	422	44.8	874	2360	912	88.4	386	229	266
Dimethyl Disulfide	0.026	145	479	2740	941	122	1560	3380	668	62.6	836	937	1180	154	265000	205000	7180	1290	2360	28300	39600
Dimethyl Sulfide	0.98	306	18700	40900	55200	274	26700	48300	7060	45.4	1130	2030	214	2220	160000	74600	30500	8460	10600	285000	383000
Ethyl Mercaptan	0.0128														5000						

Methyl Mercaptan	0.021		2750				16100				634				2700000			14500			
Trimethylamine	0.046			5200				1100				730				1000			15000	2700	
Isopropyl Alcohol			990		600		17000		8100		700			490	1700		1100		320		3200
TIC DATA																					
.ALPHA.-PINENE, (-)														902							
1,1,4-Trimethylcyclohexane														1250							
1,2-Propadiene										793											
1-Butanol								1390													
1-Butanol, 2-methyl								1360	1050												
1-Butanol, 3-methyl							568		1100												
1-Butene			266	726	744	424			889	264	1260	280	216				1160				
1-Decene, 9-methyl																					231
1-Ethyl-3-methylcyclohexane (c,t)														2440		208		323			221
1-Hexanol															1010						
1-Pentene											1360		820								
1-Propanol, 2-methyl		1060	560		655	980		350		664	650				948		407			369	294
1-Propene			1050	2010																	
1-Propene, 2-methyl		770	1610	6010	6880	847	1550		5940	1040	3270	1540	2250	602	713	5660	7330		205	1800	
1-Propyne											487										
2,2,6,6-Tetramethylheptane														1980							
2,2,7,7-Tetramethyloctane			211																		
2-Butanol				6540			62000	2380	2550		1890	438		1880	2130	916	316		219	9370	10800
2-Butanol, (R)			3990																		
2-Butanol, 3-methyl																				402	489
2-Butanone, 3-methyl				214							604						332				
2-Butenal, 2-ethenyl					309																
2-Pentanol																			480		
2-Pentanone			231	613	255				659							968	1260		1660	1170	1090
2-Pentanone, 3-methyl																	248				
2-Propanethiol															956						301
2-Propanone, 1-(ethylthio)																289					
3-Ethyl-2-hexene																					515
3-Hexyne																					297
4-Octen-3-one							2010												389		
5-Hepten-2-one, 6-methyl											276										
Acetaldehyde		2070				2110				1850				471							
Acetonitrile										281											
Benzene, 1-methyl-2-(1-methylethyl)			579		1390		3270		262		561	407	536	1010			574			985	995
Benzene, 1-methyl-4-(1-methylethyl)				890				341							381	411			1000		
Butanal, 2-methyl		1030				1650				2650											
Butanal, 3-methyl		1180				1800				2890	962										
Butane											408										
Butane, 1-chloro-3-methyl																1460					
Butanethioic acid, S-methyl ester															502						
Cyclohexane, (1,2-dimethylpropyl)						637															
Cyclohexane, 1,1,2-trimethyl							1600														
Cyclohexane, 1,1,3-trimethyl		498	393	220			6330	458	338	429	418	219		6510	640	497	283		460	274	273
Cyclohexane, 1,1-dimethyl															340				207	234	
Cyclohexane, 1,2,4-trimethyl														1880							
Cyclohexane, 1,3,5-trimethyl															220						287
Cyclohexane, 1,3-dimethyl											442					345					
Cyclohexane, 1,3-dimethyl-, cis		343	237			315	11300	2270	204	1010	216			11800	1220		213	1090	1230	261	
Cyclohexane, 1,3-dimethyl-, trans							4180							4060							
Cyclohexane, 1,4-dimethyl-, cis										296											

Cyclohexane, 1,4-dimethyl-, trans																	488			
Cyclohexane, 1-ethyl-2-methyl-, cis	203																			
Cyclohexane, 1-ethyl-2-methyl-, trans													1300	224						
Cyclohexane, 1-ethyl-4-methyl-, trans													962							
Cyclohexane, ethyl	735	414			699	8210	619	505	683	586	266	283	8610	799	602	406	793	898	475	
Cyclohexane, methyl	2510				2900	1580	2080	1350	2130	492			5410	3040			13400			
Cyclohexanone		223	860					156								340				
Cyclohexene, 1-methyl-4-(1-methylet)								224												
Cyclopentane, 1-ethyl-2-methyl-, cis													1090							
Cyclopentanol, 2-methyl																			226	
Cyclopentene, 3-ethylidene-1-methyl				220																
Cyclopropane, 1,2-dimethyl-, trans								249												
Cyclotrisiloxane, hexamethyl												244								
Decane		477	1070	633		2960	498	421		361	273		950	256		527		468	646	620
D-Limonene		446				2720				419				289		444		570	598	590
Decane, 2,2,6-trimethyl				258													305			
Decane, 2,2,8-trimethyl				254																
Decane, 2,5,6-trimethyl																				263
Decane, 5,6-dimethyl	454																			
dl-Limonene			677	1100			292								313					
Dodecane, 2,6,11-trimethyl			311													216				
Dodecane, 5-methyl																1370				
Ethanethioic acid, S-methyl ester														4440	1650				265	
Ethanol	599												758							
Ether, hexyl pentyl			1200																	1120
Ether, heptyl hexyl									239											
Furan, 2-methyl				777											565	484				
Furan, 2-pentyl				217																
Furan, tetrahydro	29400	29500	29300	19700	12100	84400	2330	10100	20300	26600	18200	19700	17600	5700	18900	20800	10500	2690	23400	24500
Heptadecane										238										
Heptane	898				994		540	266	1100				1490	999			3580	470		
Heptane, 2,2-dimethyl	406								417								625	288		
Heptane, 2,3-dimethyl		265	267		468	6210	400	349	443	506	213		5510	562	382			485	259	307
Heptane, 2,4-dimethyl	517	1460			576	5820	420	297	454	329			6210	488	357	217	659	297		
Heptane, 2,5-dimethyl		507	440		871	11400	964	762	891	833	309	324		1080	686	571	999		511	444
Heptane, 2,6-dimethyl						11500							10300							
Heptane, 2-methyl	1980	412	224		1840	22300	1310	1020	2130	895			18900	1370		352	1740	707		
Heptane, 3-methyl	1490	494	304		1510	1470	1140	901	1610	742	202		15700	1200	660	392	1260	1590	506	488
Heptane, 4-ethyl-2,2,6,6-tetramethy																	294			
Heptane, 4-methyl	430				397										237			505		
Heptane, 4-propyl													970							
Hexane, 1-(hexyloxy)-2-methyl								547												
Hexane, 2,2,3-trimethyl																				210
Hexane, 2,2,3,3-tetramethyl																			530	
Hexane, 2,2,4-trimethyl					486	4030			313											
Hexane, 2,2,5-trimethyl	381	471	355	471		6390	341			541			4930	594	289	233	532			
Hexane, 2,3-dimethyl						4220	323										582	208		
Hexane, 2,4-dimethyl	974				1010	480	815		729				2440	1090	547		265			207
Hexane, 2,5-dimethyl	711				808	661	498		594				1600		1160		4220	631	381	379
Hexane, 2-methyl													851				1800			
Hexane, 3,3-dimethyl	259				226	2500		1380	217				2990	224			322			
Hexane, 3-ethyl																283				
Hexane, 3-methyl	477				513	680			492				1040				2140			
Isobutane								257		1020										
Isopropyl Alcohol		990	5180	598		16500	1090	8080		704	725		488	1720	1030	1070		320	2660	3210
Limonene											313	378								
Methyl i-propyl disulfide														256						
Methyl isopropyl disulphide															210					

Nonane		795	84	1010	413	902	10200	1000	961	849	1170	618		8910	929	958	1090	787	1280	1150	1040
Nonane, 3-methyl							2220								279		269		467		419
Nonane, 3-methyl-5-propyl			228		419		1550														227
Nonane, 4-methyl							1660											260			
Octane		1660	1410		528	1740	21000	1730	1750	1950	1890			16900	1750	1330	1160	1250		1320	1190
Octane, 2,6-dimethyl			230	250		204		249			284			2620		305		323		401	
Octane, 2-methyl							15800					884								1190	
Octane, 3,5-dimethyl																281					
Octane, 2-methyl																		1160			
Octane, 3-methyl		901	877	834	250	954	11300	1170	951	890	1080	622	420	10300	1110	902	932	899	1920	914	858
Octane, 4-methyl		1350			334	1470		1390		1680	1860		454	16100	1350	1270			1470		
Octane, 4,5-dimethyl									206												
Oxazole, trimethyl																		785			
Pentane, 2,2,3,3-tetramethyl														2790							
Pentane, 2,2,3,4-tetramethyl														924							
Pentane, 2,3,4-trimethyl														5600							
Pentane, 2,3-dimethyl																		719			
Pentane, 2,4-dimethyl						238								1920							
Pentane, 3-ethyl-2,4-dimethyl														1640							
Pentane, 3-methyl														1720							
Propanal, 2-methyl		2900				3590				6340	1450										
Propane, 2-nitro			425	642				647									627				
Propene		450			2360	548			3020	2190	3650	1820	1990	364	251	1710	3020			849	892
Silanol, tert-butyldimethyl												1690									
Silanol, trimethyl			1120	3030	3100				1550				2320			2210	2410			706	920
trans-4,4-Dimethyl-2-hexene				354																	
Trisulfide, dimethyl	1.22				266											1620	1220			1260	1540
Undecane					263																
Undecane, 4,5-dimethyl																			296		
Undecane, 5,6-dimethyl							1560														

Compound	Days	B1	B2	B3	B4	B5
2-Butanone (MEK) (DT 737)	1	157000	143000	106000	58700	21800
	7	66600	84400	179000	126000	70600
	14	112000	72200	1150	21400	61100
	22	904	124000	512	54200	70100

Compound	Days	B1	B2	B3	B4	B5
Acetone (DT 460)	1	55400	46500	49100	15500	4530
	7	19500	24900	124000	110000	23500
	14	152000	46800	615	87000	29700
	22	2730	104000	693	140000	28500

Compound	Days	B1	B2	B3	B4	B5
Ethylbenzene	1	656	480	716	669	2180
	7	209	636	714	648	618
	14	118	296	125	246	168
	22	44.4	196	118	142	121

Compound	Days	B1	B2	B3	B4	B5
Carbon Disulfide (DT 7.7)	1	2960	3740	4270	1130	160
	7	1830	3070	4410	1950	538
	14	2510	3270	1880	2170	301
	22	3310	1080	2220	2230	381

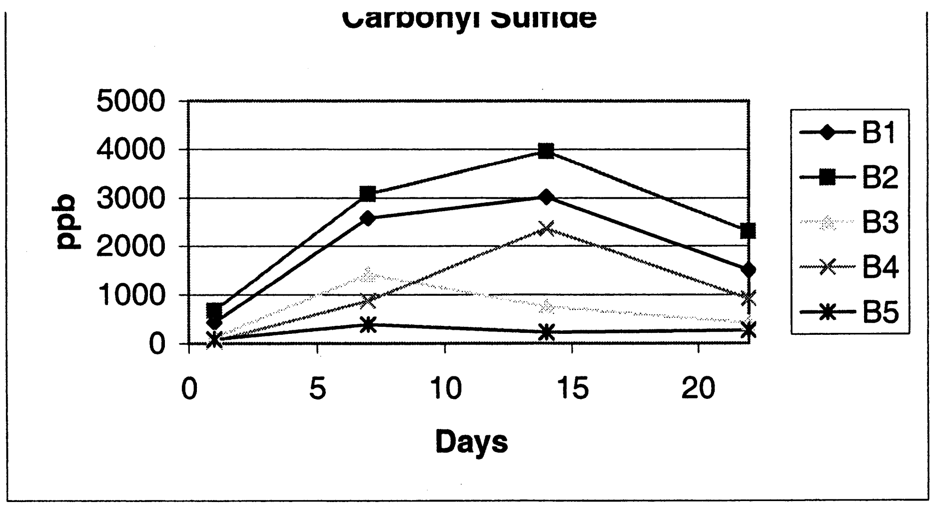
Compound	Days	B1	B2	B3	B4	B5
Carbonyl Sulfide	1	430	671	122	44.8	88.4
	7	2580	3080	1420	874	386
	14	3020	3950	754	2360	229
	22	1500	2300	422	912	266

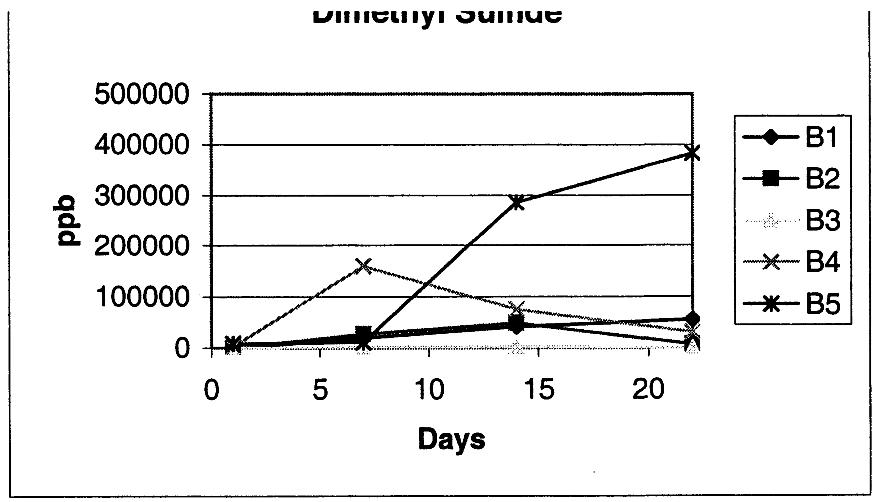
Compound	Days	B1	B2	B3	B4	B5
Dimethyl Disulfide (DT 0.026)	1	145	122	62.6	154	1290
	7	479	1560	836	265000	2360
	14	2740	3380	937	205000	28300
	22	941	668	1180	7180	39600

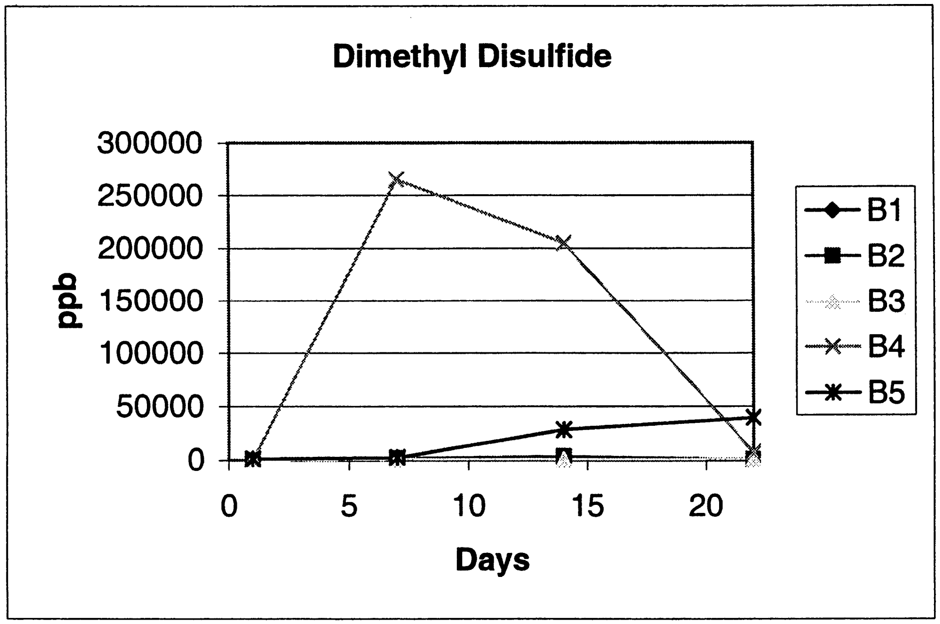
Compound	Days	B1	B2	B3	B4	B5
Dimethyl Sulfide (DT 0.98)	1	306	274	45.4	2220	8460
	7	18700	26700	1130	160000	10600
	14	40900	48300	2030	74600	285000
	22	55200	7060	214	30500	383000

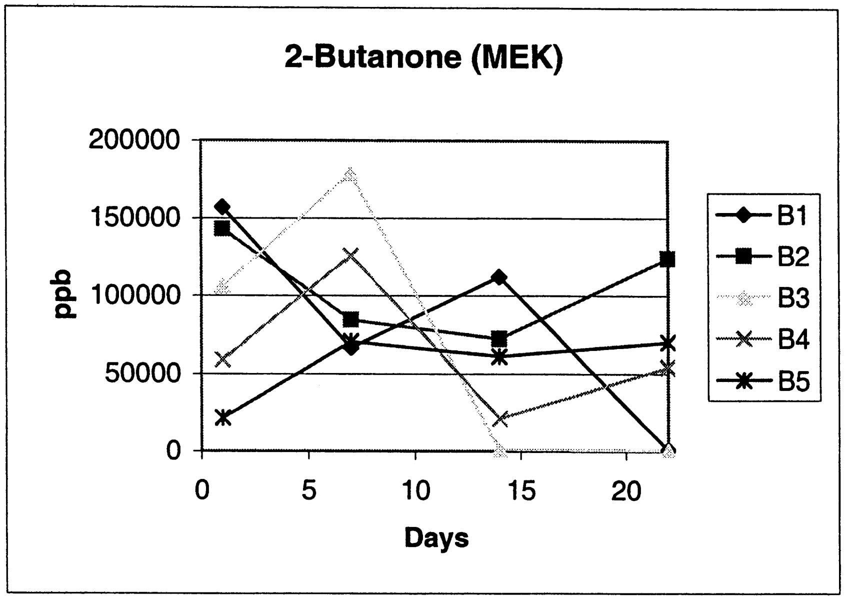
Carbonyl Sulfide

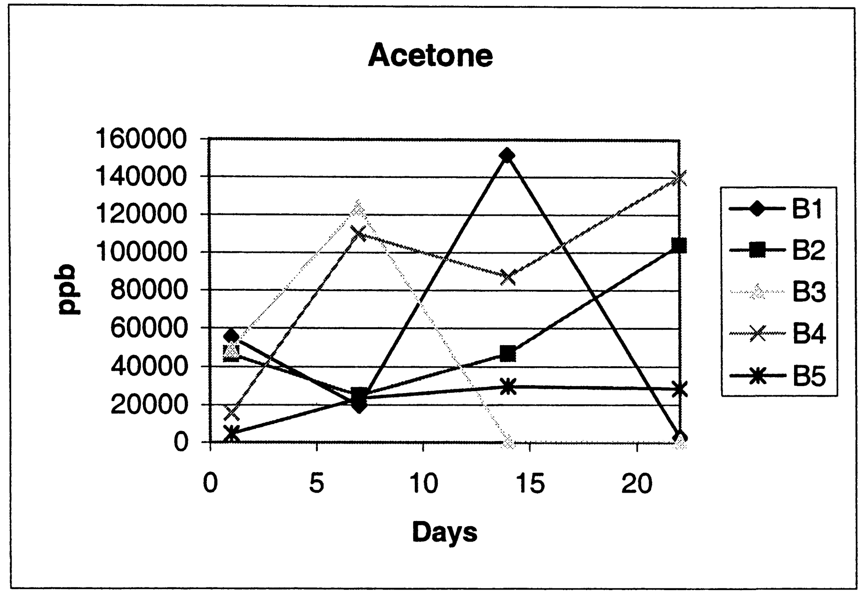
Dimethyl Sulfide

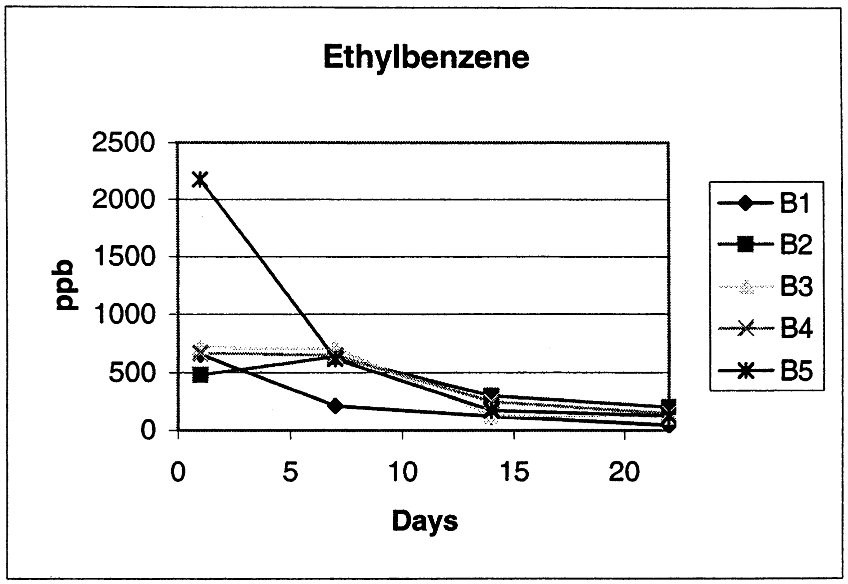

Carbonyl Sulfide
ppb
5000
4000
3000
2000
1000
0
0
5
10
15
20
Days
B1
B2
B3
B4
B5

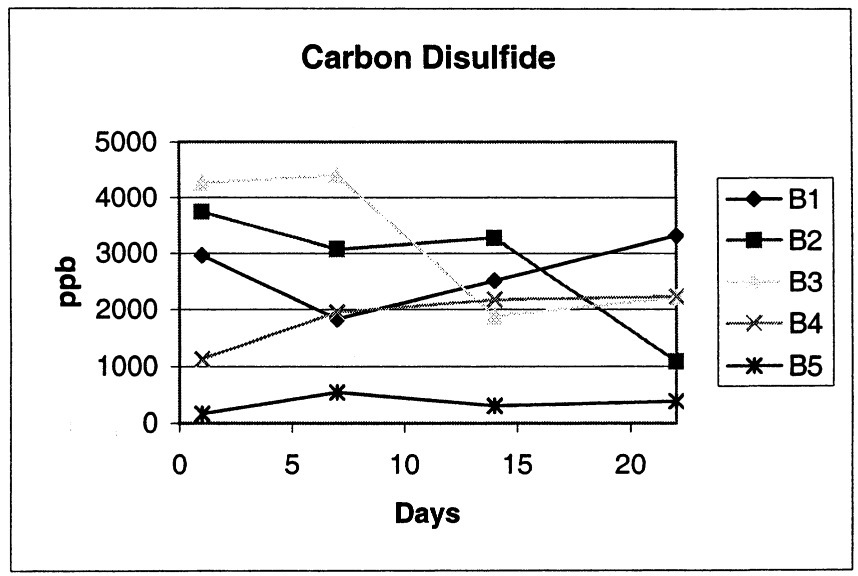

Dimethyl Sulfide
ppb
500000
400000
300000
200000
100000
0
0
5
10
15
20
Days
B1
B2
B3
B4
B5


Dimethyl Disulfide
ppb
300000
250000
200000
150000
100000
50000
0
0
5
10
15
20
Days
B1
B2
B3
B4
B5

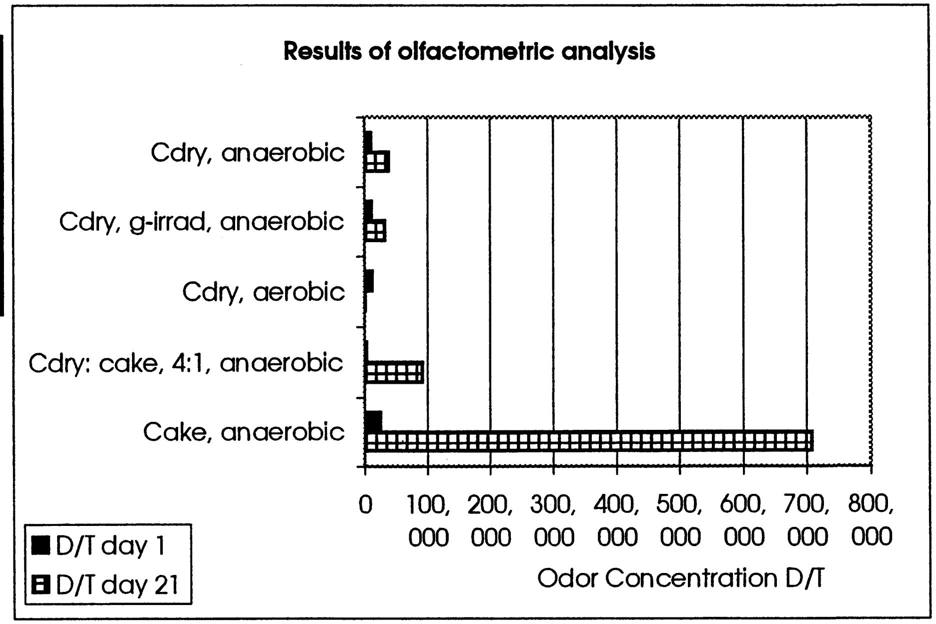

2-Butanone (MEK)
200000
150000
100000
50000
0
ppb
0
5
10
15
20
Days
B1
B2
B3
B4
B5


Acetone
160000
140000
120000
100000
80000
60000
40000
20000
0
ppb
0
5
10
15
20
Days
B1
B2
B3
B4
B5


Ethylbenzene
2500
2000
1500
1000
500
0
ppb
0
5
10
15
20
Days
B1
B2
B3
B4
B5


Carbon Disulfide
5000
4000
3000
2000
1000
0
ppb
0
5
10
15
20
Days
B1
B2
B3
B4
B5

Dilution to Threshold Results			
Bucket #	Treatment	D/T day 1	D/T day 21
1	Cdry, anaerobic	9,797	38,986
2	Cdry, γ-irrad, anaerobic	10,761	32,825
3	Cdry, aerobic	11,730	943
4	Cdry: cake, 4:1, anaerobic	2,754	92,230
5	Cake, anaerobic	25,250	707,707



5/10/00 bucket test, t=1 days					
			Dose response constants		
Bucket #	Treatment	Odor conc D/T	a	b	Odor Character
1	Cdry, anaerobic	9,797	0.92	0.53	sour garbage, rotten meat, bleach, sour compost, burnt chocolate
2	Cdry, γ-irrad, anaerobic	10,761	0.96	0.60	sour garbage, rotten meat, burnt chocolate, compost, yeasty, bread dough
3	Cdry, aerobic	11,730	0.91	0.60	sour garbge, rotten meat, smoky, sweet/burnt chocolate, compost, alcohol
4	Cdry: cake, 4:1, anaerobic	2,754	0.98	0.67	spoiled meat, burnt chocolate, sour garbage, fishy, rancid
5	Cake, anaerobic	25,250	1.04	0.85	sewage, rotten, mercaptan, fecal, manure, garbage

5/31/00 bucket test, t=21 days					
			Dose response constants		
Bucket #	Treatment	Odor conc D/T	a	b	Odor Character
1	Cdry, anaerobic	38,986	0.77	0.82	rotten, sewage, garbage, cooked cabbage, wet grass, sour, moldy
2	Cdry, γ-irrad, anaerobic	32,825	0.74	0.66	sour, rotten garbage, sewage, moldy, mildew, dead grass
3	Cdry, aerobic	943	0.69	0.90	sour, rotten grass, earthy, garbage, sewage, wet cement
4	Cdry: cake, 4:1, anaerobic	92,230	0.62	1.01	sour, rotten, garbage, mercaptan, sewage
5	Cake, anaerobic	707,707	0.78	0.84	rotten sewage, garbage, stale, sewer gas, mercaptan

CENTRIDRY PRODUCT EVALUATION: TASK 1: PRODUCT ODOR CHARACTERIZATION AND CONTROL

MICROBIOLOGY DATA REPORT

I. INTRODUCTION:

The Centridry process is a solids dewatering technology. It takes the solids from primary wastewater treatment and combines centrifugal dewatering with hot-air flash drying to produce a biosolids product (Centridry product) that is drier (53% TS) than the cake solid resulting from conventional dewatering processes (17% TS). The Centridry Demonstration Project indicated the Centridry product was suitable for reuse in land application and composting if a primary concern among end-users was resolved. This concern was for the odors given off by fresh and composted Centridry product materials.

The microbiological component of the Odor Characterization and Control Project was designed to address three separate hypotheses:

1). Biological activity causes the objectionable odors produced by the stored Centridry product over time;

2). Anaerobic and fermentative metabolism by the microbiological fractions cause the objectionable odors produced by the stored Centridry product over time;

3). The Centridry process selects for an odor-producing population by inactivating competitive populations.

[Reference: Centridry Product Evaluation: Odor Characterization and Control, Mike Boyle, 2000]

A microbial community exists in the piles of stored Centridry, and as a result of the metabolic activity occurring within this community, odorous compounds may be produced. To what extent the bacterial population of the community contributes to the pool of metabolic waste products depends on the types of bacteria present and their ability to compete in this environment. Bacterial growth in the environment is most successful when growth conditions specific to that group of bacteria are optimal. Some bacteria are equipped to survive stressful physical conditions by entering resting stages called spores. Others may be at risk for survival through competition with those bacterial populations more capable of adapting to an environment.

Bacteria differ from one another in their tolerance to different environmental conditions, the substrates they utilize as food and in their mechanisms for gaining energy. They exhibit a mixed response to the presence of molecular oxygen, allowing them to be classified as aerobes or anaerobes. Obligate aerobes grow only in the presence of oxygen. These are organisms that are dependent on aerobic respiration for the fulfillment of their energy needs. Facultative aerobes have metabolic pathways enabling them to alternate between energy-generating systems depending on the presence or absence of oxygen. At the other physiologic extreme are those bacteria which obtain energy by means of reactions that do not involve the utilization of oxygen. For many of these groups molecular oxygen is a toxic substance, which either kills them or inhibits their growth. Facultative anaerobes can grow in the presence or absence of oxygen.

The cultivation of aerobic and anaerobic microbes requires different handling and isolation techniques.

Aerobes can be grown easily on the surface of agar plates and need to be in an aerobic environment. For successful cultivation of anaerobes, the organisms must be exposed to oxygen as little as possible. Obligate anaerobes require specialized procedures in an anoxic environment through all phases of collection and isolation.

Environmental temperatures influence the maximum growth potential of bacteria. Mesophilic bacteria grow best at temperatures between 20 C and 44 C. The large proportion of bacteria belong to this group. Thermophilic bacteria grow best at temperatures between 45 C and 60 C. Elevated storage and incubation temperatures may impact the population of bacteria recovered from a sample. Thermophilic and mesophilic bacteria may be odor producing, depending on their metabolic pathways and their energy substrates.

All living organisms require a source of water. Water availability influences the type of organisms colonizing an environment and their survival rate.

The quantity and type of nutrients in an environment provide a source of cell building blocks and energy to drive the reactions involved in cell synthesis for the bacteria populating that niche. Some bacteria can utilize many compounds as growth substrate, while others are restricted to one or two substrates. These differences in nutritional requirements contribute to bacterial metabolic diversity. If the substrate (nutrient) concentration is above or below a threshhold level, the growth rate is adversely affected. When the source of energy or building blocks available to an organism is at a limited level, the growth of the organism will cease.

The Centridry product provides a unique environmental niche for a select group of bacteria that are capable of withstanding dessication (spore-formers) and heat exposure (thermoduric/thermophilic).

The Centridry product has physical characteristics that influence bacterial populations to adapt to harsh conditions. It resembles dry soil with limited water availability. The small particles of product created by drying in a very hot gas stream form a micro-environment with a dry surface and moist interior in which bacteria can grow. As the environmental conditions under which the product is stored are altered, it is likely that an evolution of bacterial populations would take place, creating new metabolic dynamics and the resultant pool of waste products.

Samples of the Centridry product stored under various conditions were collected over a time course of two weeks. These were submitted for analysis of gas phase concentrations of odorous organic compounds and quantification of bacterial populations. Comparison of the off-gas characteristics and the fractions of anaerobic and aerobic vegetative and spore-forming bacteria may provide some indication of the relationship between the volatile organic compounds and the bacterial population.

II. METHODS AND EXPERIMENTAL DESIGN

A. SAMPLE HANDLING

Test samples were collected at the Renton Treatment Plant from five storage units, or buckets, maintained under various conditions. Samples from a production lot of cake solids, Centri-feed and untreated Centridry product were included. On the last testing day, 5/25/2000, the sterilized product used to start Bucket Two, was included after two weeks of sitting at ambient conditions and not undergoing any special storage treatment. This is sample L17880-5. All samples were delivered to the Environmental Laboratory, Microbiology Section, on three different dates. The samples were processed upon receipt in the laboratory.
Sample testing included characterization of the anaerobic, aerobic and spore-forming fractions of the microbial population. This was accomplished using the heterotrophic plate count, a procedure for estimating the number of viable heterotrophic bacteria in a sample.

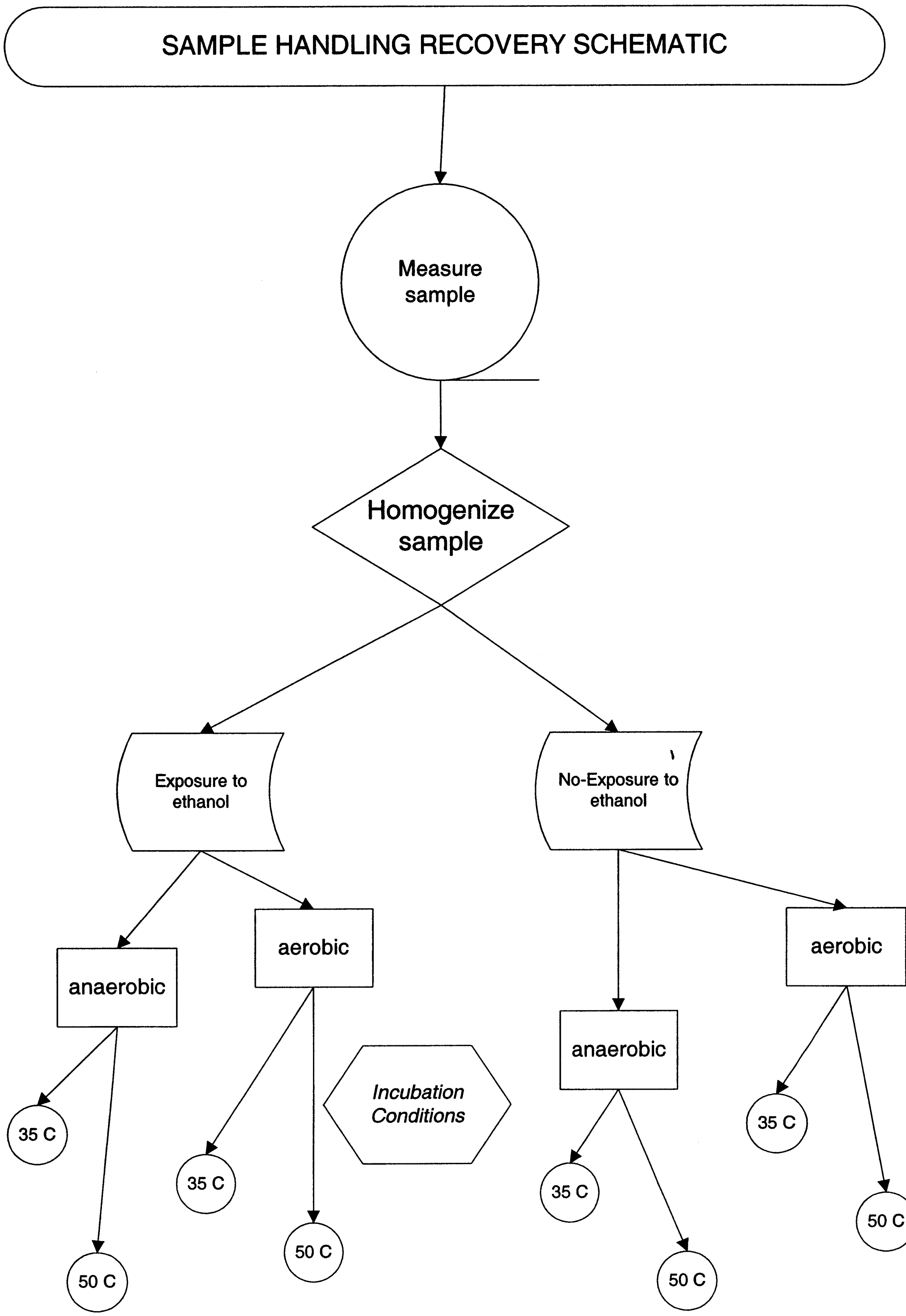
TABLE 1

L-number	Bucket description	DATE COLLECTED/PROCESSED	PRODUCT REQUESTED	DATE ANALYSIS COMPLETED
L15871 – 1,2,3	1:biosolid 2:Centri-feed 3:centri-product	5/11/2000 (Week 1)	Heterotrophic plate counts-aerobic,anaerobic Spore counts – aerobic,anaerobic	5-16-2000
L17879-1,2,3,4	1: Bucket 1: product + anaerobic conditions 2: Bucket 3: prod + aerobic conditions 3: Bucket 4: product + cake solids 4: Bucket 5: cake solids + anaerobic headspace	5/18/2000 (Week 2)	Heterotrophic plate counts-aerobic,anaerobic Spore counts – aerobic,anaerobic	5-23-2000
L17880-1,2,3,4,5	1: Bucket 1: prod + anaerobic conditions 2: Bucket 2:prod + sterilization + anaerobic conditions 3: Bucket 3: product + aerobic cond 4: Bucket 4: product + cake 5: Not Bucket: Sterilized Product – feed for bucket 2. Did not go through bucket study.	5/25/2000 (Week 3)	Heterotrophic plate counts-aerobic,anaerobic Spore counts – aerobic,anaerobic	5-30-2000

It was determined that the best approach for collection of data that would address the relationship between microbial activity and the storage conditions would be to analyze each sample received in accordance with a testing grid of three different variables:

a. Atmospheric conditions – aerobic and anaerobic
b. Temperature – mesophilic and thermophilic
c. Vegetative and spore-forming populations

Each sample was initially processed for the recovery of a select group of bacteria potentially present in the sample. A portion of a supernatant prepared from each sample was then exposed to ethanol to kill any vegetative bacterial forms, leaving the hardy spore stages for recovery on undefined isolation medium.
These two aliquots, ethanol - treated and not ethanol -treated, were then plated and incubated according to predetermined atmospheric and temperature conditions.
The two atmospheric conditions, anaerobic and aerobic, were chosen to assist in defining the bacterial populations present in the test samples. These conditions were selected to coordinate the storage conditions of the Centridry product with the recovery of two significant bacterial populations.
The temperature variations were included on the basis that some composting (elevation in temperature) might occur, or that the flash-drying step of the Centridry process might select for a thermoduric/thermophilic population.


SAMPLE HANDLING RECOVERY SCHEMATIC
Measure sample
Homogenize sample
Exposure to ethanol
No-Exposure to ethanol
anaerobic
aerobic
anaerobic
aerobic
Incubation Conditions
35 C
50 C
35 C
50 C
35 C
50 C
35 C
50 C

B. SAMPLE PROCESSING

The Standard Operating Procedure in the King County Environmental Laboratory, Microbiology Section, for processing solid samples such as biosolids, raw sewage, sediments, etc., involves taking a portion of the sample, adding APHA water and 0.5% Tween 20 to yield a 0.1% concentration. Thorough mixing occurs using a paint shaker. The supernatant is then used to inoculate appropriate test media.

The preparation of the sample homogenate is key to the optimal recovery of microbes from a solid sample. Thorough homogenization of the sample acts to remove bacteria from the sample particles and release the microbes from the interior of the sample particles. Thus the most uniform distribution of the microorganisms throughout the sample homogenate is obtained.

The Centridry product is unique from the sludge samples routinely processed in our laboratory, and for which our standard method was designed. The Centridry process, removal of moisture from sludge particles through centrifugation followed by flash-drying, produces particles that are dry on the outside, and contain moisture on the inside. This micro-environment would certainly be conducive to biological activity in the interior.

The sampling design for Week One, which included samples of Centri-feed, Centridry product and sludge, included a method modification for the processing of the Centridry product. The product was processed with the standard processing method, as well as a modified method, which included treatment for the exposure of bacteria encased in the organic sample material. Additional blending, and the addition of the surfactant Tween 20 completed the modification. The modified processing method was successful in increasing the recovery of the aerobic and anaerobic bacterial population, as well as the aerobic and anaerobic spore-forming population. Based on this preliminary recovery data, the sampling sets for Week Two and Week Three were processed using the modified SOP. The cake solid and Centri-feed samples were not processes with the modified SOP.

To enumerate of spores from the Centridry solid samples it was necessary to include an additional processing step. Absolute ethanol was added to the sample supernatant to yield a 50% solution, and, after mixture and exposure of the sample to ethanol for 15 minutes, the ethanol was neutralized and inoculation of the appropriate media completed. The ethanol treatment killed the vegetative cells in the sample, allowing the remaining spores to ex-sporulate and be recovered on the test media. (Metro MC SOP 6.14.2 & 3)

III. INCUBATION CONDITIONS

Two separate aliquots (ethanol - treated and plain sample homogenate) of each original sample were each handled for anaerobic and aerobic cultures. The atmospheric conditions dictated the choice of media and the inoculation procedure used. Approximately 95% of the anaerobe plates were inoculated under anaerobic conditions using an anaerobic –atmosphere generating system.

A. ANAEROBIC CULTURE METHODS:

MEDIA: A nutrient agar, containing compounds which lower the oxidation-reduction potential of the medium (thioglycollic acid), an oxidation-reduction potential indicator (methylene blue- allowing interpretation of the oxidation-reduction potential of the medium), and a carbohydrate (dextrose-energy source for many organisms), was used for the anaerobic heterotrophic and anaerobic spore-counting studies. These plates were poured thick, and dried thoroughly before use to maximize the discernible colony count. The plates were stored in a pre-reduced chamber before inoculation.

INOCULATION: The spread plate method of sample inoculation was used. The spread plate method does not cause heat shock and all colonies are on the agar surface where they can be easily distinguished from particles and bubbles. Colonies can be transferred quickly and colony morphology is easily discerned. This method is limited by the small volume of inoculum that can be absorbed by the agar, 0.1 – 0.5 ml, depending on the degree to which the pre-poured plates have been dried. The plate must be inoculated and spread within a five minute time period.

ATMOSPHERE: The cultivation of anaerobic bacteria requires the exclusion of atmospheric oxygen from the environment in which the growth is to take place. The recovery of facultative and obligate anaerobic bacteria is enhanced when the sample is processed and cultivation media inoculated under reduced conditions. These conditions were maintained for the inoculation and growth of the anaerobic bacteria and spore-forming population.

TEMPERATURE: The centridry process includes a hot-air fast drying step, which is exposure to a 200-300 C gas stream for seconds. The growth conditions selected for optimal growth and recovery of the microbial population included 35 C (mesophiles)and 50 C (thermophiles).

B. AEROBIC CULTURE METHODS:

MEDIA: A nutrient agar similar in composition to the anaerobic agar but without the reducing agent, was used to enumerate a variety of aerobic bacteria. These plates were poured thick and dried thoroughly before use to maximize the discernible colony count. The plates were kept at ambient atmospheric conditions.

INOCULATION: The samples were inoculated in the same fashion as the anaerobic cultures.

ATMOSPHERE: The cultivation of aerobic bacteria was accomplished in ambient air. .

These conditions were maintained for the growth of the aerobic bacteria and spore-forming population.

TEMPERATURE: The growth conditions selected for optimal growth and recovery of the microbial population included 35 C and 50 C.

IV. QUALITY CONTROL:

Routine Quality Control for Microbiology includes those procedures used to insure the quality of each batch of media, as well those procedures used to monitor method performance.

All media passed pH, sterility and positive and negative control criteria.

V. RESULTS:

Please refer to the King County Environmental Laboratory Comprehensive Lab Report for the final data on this project.

The processing of all sample sets and inoculation of all media followed the stated Experimental Design. The incubation of all plates also followed the Experimental Design, except for L17880-3. The anaerobic gas-pak jar did not reach anaerobic conditions for the isolation of spore-formers at 35 C for this sample, due to an undetected leak in the jar lid. There is no data point for L17880-3, anaerobic spore-former, 35 C. There was no way to compensate for this loss of data in the laboratory.

The following data points are calculated data figures, calculated #cfu/100 g wet weight. The ELD comprehensive report can be requested with calculated values in wet weight or dry weight #cfu/100 g. The data points were not adjusted for dry weight, due to time constraints. This should be noted when comparing the cake solid, Centri-feed, and Bucket 5, as the number of bacteria per gram of sample may be significantly affected, depending on the total solid content. Samples from Buckets One, Two, Three and Four have the same dry weight, and thus comparing the trends should hold true from wet weight data to dry weight data.

The Data Tables 2a through 2l are organized for comparison of total spore and total bacterial populations at 35 C and 50 C. This set of tables also includes the percent fraction of spore-population to the total bacterial count.

The Data Tables 3a through 3l reflect changes in bacterial populations over time at 35 C and 50 C. The blanks in these tables are an indication that the total bacterial population was comprised of predominantly spore-forming bacteria, and not vegetative cells.

The Data Tables 4a through 4l present the fractions of the aerobic and anaerobic populations in percent. The percentage of aerobic spores would be that fraction of the total spore population which is aerobic spore-formers. The vegetative value is a calculated number. It was not possible to distinguish between the facultative anaerobes, the obligate anaerobes and the facultative aerobic populations.

The Data Tables 5a – 5f present the ratio between the percentage of mesophilic and thermoduric/thermophilic populations of he spore-formers and vegetative populations.

The Data Tables 6a – 6g present the ratio of aerobic to anaerobic fractions of the vegetative and spore-forming populations.

Sample numbers are included in all tables to assist in cross-referencing the ELD comprehensive report. Those figures included inside of parentheses in the Week One (5/11/2000) testing series are numbers reflective of data sets that did not reach a detection limit of <10,000,000 at either 35 C or 50 C. These samples were retested for the total bacterial population from the original sample container five days later (5/16/2000) to reach the recorded endpoint.

The data points that have a "+" sign after the value Week Two (5/18/2000), Bucket samples One and Three, reflect the numbers of the dominant population on the given set of culture plates. The dominant population on these two samples consisted of five to seven colony types, found on gram stain to be gram positive rods, suggestive of bacillus or clostridial-type organisms. The "+" sign indicates the presence of a subpopulation of bacteria which consisted of about three colony types, found on gram stain to be slender gram positive rods and slender gram negative rods.

The LIMS Comprehensive Report contains bacterial counts isolated at 35 C; the bacterial counts isolated at 50 C are located in the text column.

The following table will clarify the terms used in the Result Section, Data Tables:

PRODUCT	*DESCRIPTION*
TOTAL AEROBE COUNT	Total counts on aerobic plates
TOTAL ANAEROBE COUNT	Total counts on anaerobic plates
TOTAL AEROBIC SPORE COUNT	Total count on aerobic spore plates
TOTAL ANAEROBIC SPORE COUNT	Total count on anaerobic spore plates
TOTAL SPORE COUNT	Total counts on anaerobic spore plates and aerobic spore plates
TOTAL VEGETATIVE AEROBIC COUNT	Total count on aerobic plate less aerobic spore count
TOTAL VEGETATIVE ANAEROBIC COUNT	Total count on anaerobic plate less anaerobic spore count
TOTAL BACTERIAL COUNT	Total counts on anaerobic and aerobic plates, less all spore counts

The following descriptions of the storage units, or buckets, are provided to assist in interpretation of the data:

BUCKET DESCRIPTIONS:

1: Product stored with anaerobic headspace (simulate storage conditions)

2: Product sterilized by gamma –irradiation and sodium azide, stored with anaerobic headspace

3: Product stored with aerobic headspace

4: Product + 20% dewatered belt press cake: (impact of moisture and microbiology changes- reinoculation of microbes) with anaerobic headspace

5: Cake solids with anaerobic headspace

DATA TABLES 2a – 2l

[Aerobic spore + Anaerobic spore = Total Spore]
[Spore count/Total Bacteria = % Spore]

35 C 2a. TOTAL BACTERIAL/SPORE COUNTS OVER TIME

L#	DATE	DESCRIPTION	TOTAL SPORE	TOTAL BACTERIA	%SPORE
L17857-3m	5/11	PRODUCT-modified	243,000	460,00	**53**
L17879-1	5/18	Bucket 1	300,000+	320,000+	**94**
L17880-1	5/25	Bucket 1	2,141,000	8,200,000	**26**

50 C 2b. TOTAL BACTERIAL/SPORE COUNTS OVER TIME

L#	DATE	DESCRIPTION	TOTAL SPORE	TOTAL BACTERIA	%SPORE
L17857-3m	5/11	PRODUCT-modified	198,000	(404,000)	**49**
L17879-1	5/18	Bucket 1	134,000+	166,000+	**74**
L17880-1	5/25	Bucket 1	4,700,000	7,800,000	**60**

35 C 2c. TOTAL BACTERIAL/SPORE COUNTS OVER TIME

L#	DATE	DESCRIPTION	TOTAL SPORE	TOTAL BACTERIA	%SPORE
L17857-3m	5/11	PRODUCT-modified	243,000	460,00	**53**
L17880-2	5/25	Bucket 2	268,000	168,000	**100**
L17880-5	5/25	Sterilized product-amb condit	560,000	29,620,000	**2**

50 C 2d. TOTAL BACTERIAL/SPORE COUNTS OVER TIME

L#	DATE	DESCRIPTION	TOTAL SPORE	TOTAL BACTERIA	%SPORE
L17857-3m	5/11	PRODUCT-modified	198,000	(404,000)	**49**
L17880-2	5/25	Bucket 2	412,000	640,000	**64**
L17880-5	5/25	Sterilized product-amb condit	350,000	730,000	**48**

35 C 2e. TOTAL BACTERIAL/SPORE COUNTS OVER TIME

L#	DATE	DESCRIPTION	TOTAL SPORE	TOTAL BACTERIA	%SPORE
L17857-3m	5/11	PRODUCT-modified	243,000	460,00	**53**
L17879-2	5/18	Bucket 3	32,000,000+	438,000+	**100**
L17880-3	5/25	Bucket 3	ND*	4,900,000	**ND**

*: anaerobic spore count not done, so not included in total spore count

50 C 2f. TOTAL BACTERIAL/SPORE COUNTS OVER TIME

L#	DATE	DESCRIPTION	TOTAL SPORE	TOTAL BACTERIA	%SPORE
L17857-3m	5/11	PRODUCT-modified	198,000	(404,000)	**49**
L17879-2	5/18	Bucket 3	109,000,000+x(numbe rs are estimates)	98,000,000+	**100**
L17880-3	5/25	Bucket 3	13,500,000	32,000,000	**42**

35 C 2g. TOTAL BACTERIAL/SPORE COUNTS OVER TIME

L#	DATE	DESCRIPTION	TOTAL SPORE	TOTAL BACTERIA	%SPORE
L17857-1	5/11	CAKE SOLID	145,000	(584,000)	**25**
L15857-3	5/11	PRODUCT-modified	243,000	460,000	**53**
L17879-3	5/18	Bucket 4	3,114,000	2,880,000	**100**
L17880-4	5/25	Bucket 4	2,116,000	1,370,000	**100**

50 C 2h. TOTAL BACTERIAL/SPORE COUNTS OVER TIME

L#	DATE	DESCRIPTION	TOTAL SPORE	TOTAL BACTERIA	%SPORE
L17857-3m	5/11	PRODUCT-modified	198,000	(404,000)	**49**
L17857-1	5/11	CAKE SOLID	51,000	(74,000)	**69**
L17879-3	5/18	Bucket 4	7,057,000	1,130,000	**100**
L17879-3	5/25	Bucket 4	5,257,000	4,125,000	**100**

35 C 2i. TOTAL BACTERIAL/SPORE COUNTS OVER TIME

L#	DATE	DESCRIPTION	TOTAL SPORE	TOTAL BACTERIA	%SPORE
L17857-1	5/11	CAKE SOLID	145,000	(584,000)	**25**
L17879-4	5/18	Bucket 5	2,120,000	270,000	**100**

50 C 2j. TOTAL BACTERIAL/SPORE COUNTS, BASELINE VALUES

L#	DATE	DESCRIPTION	TOTAL SPORE	TOTAL BACTERIA	%SPORE
L17857-1	5/11	CAKE SOLID	51,000	(74,000)	**69**
L17879-4	5/18	Bucket 5	205,000	106,000	**100**

35 C 2k. TOTAL BACTERIAL/SPORE COUNTS, BASELINE VALUES

L#	DATE	DESCRIPTION	TOTAL SPORE	TOTAL BACTERIA	%SPORE
L17857-1	5/11	CAKE SOLID	145,000	(584,000)	**35**
L17857-2	5/11	CENTRI-FEED	138,000	(4,900,000)	**3**
L17857-3	5/11	PRODUCT	47,000	(68,000)	**69**
L17857-3m	5/11	PRODUCT-modified	243,000	460,000	**53**

50 C 2l. TOTAL BACTERIAL/SPORE COUNTS OVER TIME

L#	DATE	DESCRIPTION	TOTAL SPORE	TOTAL BACTERIA	%SPORE
L17857-1	5/11	CAKE SOLID	51,000	(74,000)	**69**
L17857-2	5/11	CENTRI-FEED	78,000	(86,000)	**91**
L17857-3	5/11	PRODUCT	38,000	34,000	**93**
L17857-3m	5/11	PRODUCT- modified	198,000	590,000	**3**

DATA TABLES 3a – 3l

[Aerobic, bact - Aerobic,spore = Aerobic vegetative cells]

35 C 3a. AEROBIC AND ANAEROBIC BACTERIAL COUNTS

L#	Date	Description	Aerobic,bact	Aerobic, spore	Aero,veg	Anaero,bact	Anaerob,spore	Ana,veg
L17571-3m	5/11	Product	190,000	83,000	107,000	270,000	160,000	110,000
L17879-1	5/18	Bucket 1	120,000+	100,000+	20,000	200,000+	200,000	
L17880-1	5/25	Bucket 1	3,100,000	41,000	3,059,000	*5,100,000*	2,100,000	3,000,000

50 C 3b. AEROBIC AND ANAEROBIC BACTERIAL COUNTS

L#	Date	Description	Aerobic,bact	Aerobic, spore	Aero,veg	Anaero,bact	Anaerob,spore	Ana,veg
L17571-3m	5/11	Product	(84,000)	58,000	26,000	320,000	140,000	180,000
L17879-1	5/18	Bucket 1	150,000+	100,000+	50,000	16,000+	34,000	
L17880-1	5/25	Bucket 1	2,700,000	1,600,000	1,100,000	5,100,000	3,100,000	2,100,000

35 C 3c. AEROBIC AND ANAEROBIC BACTERIAL COUNTS

L#	Date	Description	Aerobic,bact	Aerobic, spore	Aero,veg	Anaero,bact	Anaerob,spore	Ana,veg
L17571-3m	5/11	Product	190,000	83,000	107,000	270,000	160,000	*110,000*
L17880-2	5/25	Bucket 2	20,000	38,000		140,000	230,000	
L17880-5	5/25	PROD +AZID	29,000,000	240,000	28,750,000	620,000	320,000	300,000

50 C 3d. AEROBIC AND ANAEROBIC BACTERIAL COUNTS

L#	Date	Description	Aerobic,bact	Aerobic, spore	Aero,veg	Anaero,bact	Anaerob,spore	Ana,veg
L17571-3m	5/11	Product	84,000	58,000	26,000	320,000	140,000	180,000
L17880-2	5/25	Bucket 2	40,000	52,000		600,000	360,000	240,000
L17880-5	5/25	PROD+AZ	500,000	13,000	481,000	250,000	18,000	232,000

35 C 3e. AEROBIC AND ANAEROBIC BACTERIAL COUNTS

L#	Date	Description	Aerobic,bact	*Aerobic, spore*	Aero,veg	Anaero,bact	Anaerob,spore	Anaero,veg
L17571-3	5/11	Product	190,000	83,000	107,000	270,000	160,000	110,000
L17879-2	5/18	Bucket 3	420,000+	12,000,000+		18,000+	20.000,000+	
L17880-3	5/25	Bucket 3	4,100,000	2,400,000	1,700,000	8,000,000	ND	

50 C 3f. AEROBIC AND ANAEROBIC BACTERIAL COUNTS

L#	Date	Description	*Aerobic,bact*	*Aerobic, spore*	Aero,veg	Anaero,bact	Anaerob,spore	Anaero,veg
L17571-3m	5/11	Product	84,000	58,000	26,000	320,000	140,000	180,000
L17879-2	5/18	Bucket 3	1,000,000+	22000000+		97,000,000	87,000,000+	10,000,000
L17880-3	5/25	Bucket 3	20,000,000	3,500,000	16,500,000	12,000,000	10,000,000	2,000,000

35 C 3g. AEROBIC AND ANAEROBIC BACTERIAL COUNTS

L#	Date	Description	Aerobic,bact	Aerobic, spore	Aerobic,veg	Anaero,bact	Anaerob,spore	Anaerob,veg
L17571-3	5/11	Product	190,000	83,000	107,000	270,000	160,000	110,000
L17571-1	5/11	Cake	(530,000)	90,000	440,000	(54,000)	55,000	
L17879-3	5/18	Bucket 4	180,000	14,000	166,000	2,700,000	3,100,000	
L17880-4	5/25	Bucket 4	70,000	16,000	54,000	2,100,000	1,300,000	800,000

50 C 3h. AEROBIC AND ANAEROBIC BACTERIAL COUNTS

L#	Date	Description	Aerobic,bact	Aerobic, spore	Aerobic,veg	Anaero,bact	Anaerob,spore	Anaerob,veg
L17571-3m	5/11	Product	84,000	58,000	26,000	320,000	140,000	180,000
L17571-1	5/11	Cake	49,000	40,000	9,000	25,000	11,000	14,000
L17879-3	5/18	Bucket 4	1,000,000	57,000	943,000	130,000	7,000,000	
L17880-4	5/25	Bucket 4	25,000	57,000		410,000	5,200,000	

35 C 3i. AEROBIC AND ANAEROBIC BACTERIAL COUNTS

L#	Date	Description	Aerobic,bact	Aerobic, spore	Aerobic,veg	Anaero,bact	Anaerob,spore	Anaerob,veg
L17571-1	5/11	Cake	(530,000)	90,000	440,000	(54,000)	55,000	
L17879-4	5/18	Bucket 5	160,000	120,000	40,000	110,000	2,000,000	

50 C 3j. AEROBIC AND ANAEROBIC BACTERIAL COUNTS

L#	Date	Description	Aerobic,bact	Aerobic, spore	Aerobic,veg	Anaero,bact	Anaerob,spore	Anaerob,veg
L17571-1	5/11	Cake	49,000	40,000	9,000	25,000	11,000	14,000
L17879-4	5/18	Bucket 5	62,000	45,000	17,000	44,000	160,000	

35 C 3k. AEROBIC AND ANAEROBIC BACTERIAL COUNTS

L#	Date	Description	Aerobic,bact	Aerobic, spore	Aerobic,veg	Anaero,bact	Anaerob,spore	Anaerob,veg
L17571-1	5/11	Cake	(530,000)	90,000	440,000	(54,000)	55,000	
L17857-2	5/11	Centri-feed	2,000,000	60,000	1,940,000	1,500,000	100,000	1,400,000
L17571-3m	5/11	Product	190,000	83,000	107,000	270,000	160,000	110,000
L17571-3	5/11	Product-no mod	27,000	7,300	19,700	41,000	40,000	37,000

50 C 3l. AEROBIC AND ANAEROBIC BACTERIAL COUNTS

L#	Date	Description	Aerobic,bact	Aerobic, spore	Aerobic,veg	Anaero,bact	Anaerob,spore	Anaerob,veg
L17571-1	5/11	Cake	49,000	40,000	9,000	25,000	11,000	14,000
L17857-2	5/11	Centri-feed	56,000	48,000	8,000	30,000	30,000	
L17571-3m	5/11	Product	270,000	58,000	212,000	320,000	140,000	180,000
L17571-3	5/11	Product-no mod	28,000	22,000	***6,000***	13,000	16,000	

DATA TABLES 4a – 4l

[aerobic spore/aerobic bacteria X 100 = % aerobic spore of aerobic population]
[100 - % aerobic spore = % aerobic vegetative cells]

35 C 4a. FRACTIONS OF AEROBIC AND ANAEROBIC BACTERIA

L#	Date	Description	%Aerobic, spore	%Aero, vegetative	%Anaerob, spore	%Ana, vegetative
L17571-3m	5/11	Product	44	56	*59*	*41*
L17879-1	5/18	Bucket 1	83	17	*91*	*9*
L17880-1	5/25	Bucket 1	1	99	*41*	*59*

50 C 4b. FRACTIONS OF AEROBIC AND ANAEROBIC BACTERIA

L#	Date	Description	%Aerobic, spore	%Aero, vegetative	%Anaerob, spore	%Ana, vegetative
L17571-3m	5/11	Product	69	31	44	56
L17879-1	5/18	Bucket 1	67	33	100	
L17880-1	5/25	Bucket 1	59	41	61	41

35 C 4c. FRACTIONS OF AEROBIC AND ANAEROBIC BACTERIA

L#	Date	Description	%Aerobic, spore	%Aero, vegetative	%Anaerob, spore	%Ana, vegetative
L17571-3m	5/11	Product	44	56	59	41
L17880-2	5/25	Bucket 2	100		100	
L17880-5	5/25	Azide+prod	1	99	23	77

50 C 4d. FRACTIONS OF AEROBIC AND ANAEROBIC BACTERIA

L#	Date	Description	%Aerobic, spore	%Aero, vegetative	%Anaerob, spore	%Ana, vegetative
L17571-3m	5/11	Product	69	31	44	56
L17880-2	5/25	Bucket 2	100		51	48
L17880-5	5/25	Azide + prod	42	58	60	40

35 C 4e. FRACTIONS OF AEROBIC AND ANAEROBIC BACTERIA

L#	Date	Description	%Aerobic, spore	%Aero, vegetative	%Anaerob, spore	%Anaerob, vegetative
L17571-3m	5/11	Product	44	*56*	59	41
L17879-2	5/18	Bucket 3	*100*		100	
L17880-3	5/25	Bucket 3	58	*42*	Nd	Nd

50 C 4f. FRACTIONS OFAEROBIC AND ANAEROBIC BACTERIA

L#	Date	Description	%Aerobic, spore	%Aero, vegetative	%Anaerob, spore	%Anaerob, vegetative
L17571-3m	5/11	Product	69	*31*	44	56
L17879-2	5/18	Bucket 3	100		90	10
L17880-3	5/25	Bucket 3	17	*83*	83	17

35 C 4g. FRACTIONS OF AEROBIC AND ANAEROBIC BACTERIA

L#	Date	Description	%Aerobic, spore	%Aero, vegetative	%Anaerob, spore	%Anaerob, vegetative
L17571-3m	5/11	Product	4	56	59	56
L17571-1	5/11	Cake	17	83	100	
L17879-3	5/18	Bucket 4	8	92	100	
L17880-4	5/25	Bucket 4	23	77	62	38

50 C 4h. FRACTIONS OF AEROBIC AND ANAEROBIC BACTERIA

L#	Date	Description	%Aerobic, spore	%Aero, vegetative	%Anaerob, spore	%Anaerob, vegetative
L17571-3m	5/11	Product	69	31	44	56
L17571-1	5/11	Cake	82	18	44	56
L17879-3	5/18	Bucket 4	6	94	100	
L17880-4	5/25	Bucket 4	100		100	

35 C 4i.FRACTIONS OF AEROBIC AND ANAEROBIC BACTERIA

L#	Date	Description	%Aerobic, spore	%Aero, vegetative	%Anaerob, spore	%Anaerob, vegatative
L17571-1	5/11	Cake	17	83	100	
L17879-4	5/18	Bucket 5	75	25	0	0

50 C 4j. FRACTIONS OF AEROBIC AND ANAEROBIC BACTERIA

L#	Date	Description	%Aerobic, spore	%Aero, vegetative	%Anaerob, spore	%Anaerob, vegetative
L17571-1	5/11	Cake	82	18	44	56
L17879-4	5/18	Bucket 5	73	27	100	

35 C 4k. FRACTIONS OF AEROBIC AND ANAEROBIC BACTERIA

L#	Date	Description	%Aerobic, spore	%Aero, vegetative	%Anaerob, spore	%Anaerob, vegetative
L17571-1	5/11	Cake	17	83	100	
L17857-2	5/11	Centri-feed	3	97	7	93
L17857-3m	5/11	Product	44	56	59	41
L17857-3	5/11	Prod – no mod	27	73	98	2

50 C 4l.FRACTIONS OF AEROBIC AND ANAEROBIC BACTERIA

L#	Date	Description	%Aerobic, spore	%Aero, vegetative	%Anaerob, spore	%Anaerob, vegetative
L17571-1	5/11	Cake	82	18	44	56
L17857-2	5/11	Centri-feed	86	14	100	
L17857-3m	5/11	Product	21	78	44	56
L17857-3	5.11	Prod – no mod	79	21	98	2

DATA TABLES 5a – 5f

5a. **% MESOPHILE : % THERMOPHILE**
(35 C: 50 C)

	PRODUCT	RATIO
SPORE	53:49	1
VEGETATIVE	47:51	1

	BUCKET 1	RATIO
SPORE	26:60	1/3
VEGETATIVE	74:40	2

5b. **% MESOPHILE : % THERMOPHILE**
(35 C: 50 C)

	PRODUCT	RATIO
SPORE	53:49	1
VEGETATIVE	47:51	1

	BUCKET 2	RATIO
SPORE	100:64	2
VEGETATIVE	0:36	0

5c. **% MESOPHILE : % THERMOPHILE**
(35 C: 50 C)

	PRODUCT	RATIO
SPORE	53:49	1
VEGETATIVE	47:51	1

	BUCKET 3	RATIO
SPORE	Nd	Nd
VEGETATIVE	Nd	nd

5d. **% MESOPHILE : % THERMOPHILE**

(35 C: 50 C)

	PRODUCT	RATIO
SPORE	53:49	1
VEGETATIVE	47:51	1

	CAKE	RATIO
SPORE	25:69	1/3
VEGETATIVE	75:31	3

	BUCKET 4	RATIO
SPORE	100:0	100
VEGETATIVE	0:100	0

5e. **% MESOPHILE : % THERMOPHILE**

(35 C: 50 C)

	CAKE	RATIO
SPORE	25:69	1/3
VEGETATIVE	75:31	3

	BUCKET 5	RATIO
SPORE	100:100	1
VEGETATIVE	0:0	

5f. **% MESOPHILE : % THERMOPHILE**

(35 C: 50 C)

	PRODUCT	RATIO
SPORE	53:49	1
VEGETATIVE	47:51	1

	Prod/steril	RATIO
SPORE	2:48	1/24
VEGETATIVE	98:52	2

Data Tables 6a – 6g

6a. RATIO OF AEROBIC AND ANAEROBIC POPULATION FRACTIONS

Bucket One:

50,C, product, 5/11	Aerobic incubatiion	Anaerobic incubation
Vegetative population	2.6e4	1.8e5
Spore-forming population	5.8e4	1.4e5

50,C, Bucket 1,5/25	Aerobic incubation	Anaerobic incubation
Vegetative population	1.1e6	2.1e6
Spore-forming population	1.6e6	3.1e6

AEROBIC COUNT: ANAEROBIC COUNT

	PRODUCT	RATIO
SPORE	5.8:14	½
VEGETATIVE	2.6:18	1/8

AEROBIC COUNT: ANAEROBIC COUNT

	BUCKET 1	RATIO
SPORE	16:31	½
VEGETATIVE	11:21	½

6b. RATIO OF AEROBIC AND ANAEROBIC POPULATION FRACTIONS

Bucket Two:

35 C, product, 5/11	Aerobic incubation	Anaerobic incubation
Vegetative population	1e5	1.1e5
Spore-forming population	8e4	1.6e5

35 C, Bucket 2,5/25	Aerobic incubation	Anaerobic incubation
Vegetative population	0	0
Spore-forming population	3.8e4	2.3e4

AEROBIC COUNT: ANAEROBIC COUNT

	PRODUCT	RATIO
SPORE	8:16	2
VEGETATIVE	1:1.1	1

AEROBIC COUNT: ANAEROBIC COUNT

	BUCKET 2	RATIO
SPORE	3.8:2.3	1/2
VEGETATIVE	0:0	

6c. RATIO OF AEROBIC AND ANAEROBIC POPULATION FRACTIONS

Bucket Three:

50 C, product, 5/11	Aerobic incubation	Anaerobic incubation
Vegetative population	2.6e4	1.8e5
Spore-forming population	5.8e4	1.4e5

50 C, Bucket 3,5/25	Aerobic incubation	Anaerobic incubation
Vegetative population	16.5e6	2e6
Spore-forming population	3.5e6	10e6

AEROBIC COUNT: ANAEROBIC COUNT

	PRODUCT	RATIO
SPORE	5.8:14	½
VEGETATIVE	2.6:18	1/8

AEROBIC COUNT: ANAEROBIC COUNT

	BUCKET 1	RATIO
SPORE	2.6:18	1/8
VEGETATIVE	16.5:2	8

6d. RATIO OF AEROBIC AND ANAEROBIC POPULATION FRACTIONS
Bucket four:

35 C, product, 5/11	Aerobic incubation	Anaerobic incubation
Vegetative population	1e5	1.1e5
Spore-forming population	8e4	1.6e5

35 C, cake,5/11	Aerobic incubation	Anaerobic incubation
Vegetative population	4.4e4	
Spore-forming population	9e4	5.5e4

35 C, Bucket 4,5/18	Aerobic incubation	Anaerobic incubation
Vegetative population	5.4e4	8e5
Spore-forming population	1.6e4	5e61.3e6

.

AEROBIC COUNT: ANAEROBIC COUNT

	PRODUCT	RATIO
SPORE	8:16	2
VEGETATIVE	1:1.1	1

AEROBIC COUNT: ANAEROBIC COUNT

	CAKE	RATIO
SPORE	9:5.5	2
VEGETATIVE	4.4:0	½

AEROBIC COUNT: ANAEROBIC COUNT

	BUCKET 4	RATIO
SPORE	1:250	1/250
VEGETATIVE	5.4:80	16

6e. RATIO OF AEROBIC AND ANAEROBIC POPULATION FRACTIONS

Bucket Five:

35 C, cake,5/11	Aerobic incubation	Anaerobic incubation
Vegetative population	4.4e4	
Spore-forming population	9e4	5.5e4

35 C, Bucket 5, 5/18	Aerobic incubation	Anaerobic incubation
Vegetative population	4e4	
Spore-forming population	1.2e6	2e6

AEROBIC COUNT: ANAEROBIC COUNT

	CAKE	RATIO
SPORE	9:5.5	2
VEGETATIVE	4.4:0	

AEROBIC COUNT: ANAEROBIC COUNT

	BUCKET 5	RATIO
SPORE	120:3	40
VEGETATIVE	4:0	½

6f. RATIO OF AEROBIC AND ANAEROBIC POPULATION FRACTIONS

Pre-sterilized product:

35 C, product, 5/11	Aerobic incubation	Anaerobic incubation
Vegetative population	1e5	1.1e5
Spore-forming population	8e4	1.6e5

35 C, product + azide,5/25	Aerobic incubation	Anaerobic incubation
Vegetative population	29e6	3e5
Spore-forming population	2.4e5	3.2e5

AEROBIC COUNT: ANAEROBIC COUNT

	PRODUCT	RATIO
SPORE	8:16	1/2
VEGETATIVE	1:1.1	1

AEROBIC COUNT: ANAEROBIC COUNT

	PROD/STER	RATIO
SPORE	2.4:32	1/16
VEGETATIVE	290:3	100

6g. RATIO OF AEROBIC AND ANAEROBIC POPULATION FRACTIONS

Centrifeed compared to product:

35,C, product, 5/11	Aerobic incubation	Anaerobic incubation
Vegetative population	1e5	1.1e5
Spore-forming population	8e4	1.6e5

35 C, Centri-feed, 5/11	Aerobic incubation	Anaerobic incubation
Vegetative population	8e4	
Spore-forming population	4.8e4	3e4

AEROBIC COUNT: ANAEROBIC COUNT

	PRODUCT	RATIO
SPORE	8:16	2
VEGETATIVE	1:1.1	1

AEROBIC COUNT: ANAEROBIC COUNT

	CENTRI-FEED	RATIO
SPORE	4.8:3	1
VEGETATIVE	8:0	

VI. DISCUSSION:

The Centridry Process is a wastewater treatment technology that is being investigated as an alternative to anaerobic digestion in the treatment of the wastewater stream. It requires a primary gravity treatment step of raw sewage and anaerobic digestion of the solids, with a two-step process of centrifugation and hot-air flash drying to produce the Centridry product, instead of a digested cake solid. The microbial population introduced through the raw sewage of a community remains the source of any bacterial population of concern in the product. The end result of the wastewater treatment flow depends on how the microbial population is influenced during the treatment process. Likewise, the microbial characteristics of the end-product of a given wastewater treatment technology depends on the handling of the product. Thus, we have the basic premise that if the bacterial population of a treatment product is the cause of unacceptable qualities of that product, we need to change the footprint of that population. This can be done through the addition of a competing bacterial population (bioremediation), the elimination of the causative bacterial population (altering the required physical conditions – temperature, atmosphere, nutrient load), or through the manipulation of the bacterial population (again, altering the required physical conditions). The success of any or all of these alterations could effectively change the dynamics of the bacterial populations and consequently, the negative qualities of the product.
The Odor Characterization Study attempted to identify any relationships between odor production and the bacterial metabolic activity occurring prior to and after the Centridry process, as well as when the Centridry product was stored under varying conditions. It was necessary to determine a baseline picture of the bacterial populations present in the components of the study...cake solid, Centri-feed and the Centridry product. This would allow recognition of the changes occurring throughout the testing period.
The Centridry feed stock, Centri-feed, was cultured to determine the presence and quantity of anaerobic and aerobic spore-forming and vegetative populations, at mesophilic (35 C) and thermophilic (50 C) temperatures. The aerobic and anaerobic vegetative and spore-forming bacteria were quantified using standard plate count methods. We could not differentiate between the obligate anaerobic population and the obligate aerobic population, as we did not attempt identification to genus level for these broad groups of bacteria
The ability to form endospores from the vegetative state is not inherent in all bacteria. However, the spore-forming bacteria have certain general properties, in addition to spore formation, which suggests they constitute a large natural group. Typically, they are gram-positive rod-shaped cells. Their modes of energy-yielding metabolism include aerobic and anaerobic respiration and fermentation. The typical habitat for most spore-formers is soil.
The primary taxonomic subdivision of spore-formers is based on their relation to free oxygen. The anaerobic spore-formers (Clostridia) are obligate anaerobes. The aerobic spore-formers (Bacillus) are obligate aerobes or facultative anaerobes. Most aerobic spore-formers are mesophiles, although the group includes a number of thermotolerant and thermophilic members.

Bacterial activity as defined by bacterial growth occurred in all test samples. There was a decrease in total bacterial growth from the Centri-feed to the Centridry product due to the Centridry process (Tables 2k & 2l). This had been demonstrated during the Centridry Pilot Project and was observed during the initial baseline sampling of the Centri-feed and Centridry product of the Odor Characterization Project. The reduction in bacterial numbers from the Centri-feed to the Centridry product was consistent for the total bacterial population, and the spore-forming population (Tables 2k & 2l). The composition of the bacterial population in the product was altered by the Centridry process. The Centri-feed sample had much higher ratios of mesophilic to thermophilic vegetative cells and a lower ratio of mesophilic to thermophilic spore-forming cells (Table 5g). The value for the mesophilic total bacteria of the Centri-feed sample appears to be a weak data point, as it is not consistent with the rest of the data for this sample. The aerobic and anaerobic populations of the total bacteria were high compared to the other data points in this sample set, and the vegetative cells formed the dominant portion of both populations. The spore-forming counts, aerobically and anaerobically were in line with the rest of the data set (Tables 3k & 3l). After the Centridry processing, the ratios of mesophilic to thermophilic spore-formers and vegetative cells were the similar (Table 5g). The proportion of aerobic to anaerobic vegetative cells increased after the Centridry process and the proportion of aerobic to anaerobic spores decreased (Table 6g).

The drying process of the Centridry technology and the formation of intact particles could contribute to the increased proportion of anaerobic spore-forming bacteria to aerobic spore-forming bacteria. The change in the mesophilic and thermophilic populations are difficult to account for. There is a flash-heating step that may affect the survival rate of the mesophilic vegetative population, and not the thermophilic population. Vegetative bacteria are not equipped to survive exposure to high temperatures and their numbers would be reduced; the elevated temperature exposure, even though brief, may be trigger enough to cause ex-sporulation of the thermophilic sporeformers. This could explain the equal ratios of mesophilic to thermophilic vegetative and spore-forming bacterial populations in the product.

A basic premise of the Odor Characterization Study is that bacteria produce malodorous compounds via an assortment of metabolic pathways. If the bacterial populations present in the Centridry product, when kept under known storage conditions, produce these 'objectionable' odors, it would follow that changing the conditions of storage might change the bacterial population and hence, the metabolic waste products causing the odors.

Four storage conditions were designed to produce changes in the bacterial components, qualitatively and quantitatively, of the Centridry product when stored over time. The testing time was two weeks.
All of the storage units were held in a waterbath at 60 C. There were three starting materials in various combinations used for testing storage conditions: Cake solid, Centridry product, and Centridry product with sterilization treatment.

The Centridry product was tested under two different storage conditions where the only variable was the atmospheric content of the bucket headspace.
Test Condition One (Bucket One) stored the Centridry product, in a chamber flushed with nitrogen to create an anaerobic atmosphere. The atmospheric and temperature conditions of an environment are important factors in determining what bacteria will colonize and survive in a given environment. The total number of bacteria isolated from the Centridry product at the conclusion of the anaerobic storage period increased from the total number of bacteria recovered at the start of the storage study period. This increase included both spore-formers and vegetative cells (Tables 2a & 2b). The Centridry product provides sufficient substrates to support a diverse and metabolically active population of bacteria. The resultant metabolic end-products contribute to the pool of available substrates, maintaining a threshhold of nutrients capable of sustaining growth for at least the testing period.
The total spore-forming population increased over the two week testing period, but the percentage of anaerobic spore-formers of the total bacterial population decreased at mesophilic temperatures and increased at elevated temperatures (Tables 2a & 2b, Tables 4a & 4b). The ratio of mesophilic vegetative cells to thermophilic vegetative cells decreased over the testing period (Table 5a). The proportion of anaerobic to aerobic vegetative bacteria decreased over time in the stored product (Table 6a).
An unusual phenomenon was observed at testing week two (5/18/2000). Two different and distinct groups of colony types were seen on all of the testing media. The size and growth pattern of the dominant population was distinct from the second group of colonies identified as a subpopulation. This phenomenon also occurred on the sample from testing conditions Bucket Three, and will be reviewed under the discussion of Bucket Three bacterial data.
The anaerobic storage condition for Bucket One did not seem to cause an increase in the proportion of anaerobic bacteria. There did seem to be a temperature effect between the mesophilic and thermophilic bacterial population. The anaerobic and aerobic spore-formers demonstrated better growth at 50 C (thermophilic temperature), while the anaerobic and aerobic vegetative population demonstrated better growth at 35 C (mesophilic temperature). The storage containers were held in waterbaths at 60 C. This could selectively effect the growth of thermophilic bacteria capable of growing at elevated temperatures.

Test ConditionThree (Bucket Three), stored the Centridry product under aerobic conditions. The total mesophilic and thermophilic bacterial populations increased in number from the starting product, over the two week testing period (Tables 2e & 2f). The thermophilic aerobic and anaerobic bacterial populations increased (Tables 3e & 3f), however, there was a greater number of aerobic thermophilic vegetative cells than anaerobic thermophilic vegetative cells, probably due to the aeration of the bucket and the storage temperature (Tables 3e & 3f). The mesophilic aerobic spore-formers and vegetative cells were present in equal proportions in the bucket sample (Table 4e). This equivalent relationship between mesophilic aerobic bacteria shifted under thermophilic conditions, to a substantial increase in the proportion of aerobic spore-formers to the vegetative population (Table 4f). The mesophilic anaerobic portion of the spore population was not determined due to a lab error, where anaerobiosis was not attained at 35 C (Table 4e). However, the ratio of thermophilic aerobic spore-formers to anaerobic spore-formers decreased over time while the ratio of thermophilic aerobic vegetative cells to vegetative cells increased (Table 6c). The hole in this sample data (mesophilic anaerobic spore count) makes it difficult to substantiate any differences between the mesophilic aerobic and anaerobic populations. Coupled with the occurrence of the subpopulation during the second week of testing, this sample data set is difficult to interpret. In general, we can say the bacterial populations increased at both mesophilic and thermophilic temperatures under both aerobic and anaerobic conditions. The ratio of the thermophilic aerobic to anaerobic spore-forming population decreased while the ratio of the thermophilic aerobic to anaerobic vegetative population increased. No elaboration can be made on the differentiation between the mesophilic aerobic and anaerobic bacterial populations.

An unusual phenomenon was observed during the review of all of the plating media for testing of Bucket Three, 5/18/2000. Throughout each dilution series, on all of the culture media regardless of temperature, atmospheric incubation conditions, we observed a dominant group of colony types, consistent in appearance to previous colonies seen on the baseline sample from 5/11/2000, and a second, subpopulation of colony types which we had not observed on the baseline sample from 5/11/2000. There was no apparent laboratory error that would result in the appearance of this subpopulation, as not all of the samples from this testing date exhibited the recovery of a secondary population. During our examination of the set of incubated plates for this sample, we noted that the dominant population demonstrated a dilution effect, per inoculation, while the subpopulation did not. The subpopulation would maintain colony counts too numerous too count on three dilution plates in a series, and on the fourth it would disappear, at which point we would recover the dominant population, and no subpopulation. The colonial appearance between the dominant population and the subpopulation was distinct and different, as was the similar appearance between each group of colonies making up the subpopulation. This was not a contamination problem.

It is possible this incident was induced by the production of a waste product from the dominant population which enhanced the growth of the secondary population. If a certain threshhold of the byproduct from the metabolic activity of the dominant organisms was maintained, the subpopulation thrived. At that point where the dominant population was reduced in numbers (by dilution) such that the threshhold of the by-product was not met, the subpopulation disappeared. The occurrence of a dominant and subdominant group of colony types made it difficult to interpret the data for the sampling set of 5/18/2000.

The aerobic and anaerobic thermophilic bacterial populations also increased (Tables 3e & 3f),

Test Condition Two (Bucket Two) involved taking the Centridry product, treating with gamma irradiation and sodium azide to reach 'sterilization' of the product and then storing it under anaerobic conditions.

This 'sterilized' product was also stored at ambient room conditions for two weeks, and a bacterial survey done of the population. This was not a 'Bucket' storage condition.

The "sterilized' Centridry product was not tested for bacterial growth immediately after sterilization treatment to determine a baseline value. The Centridry product without sterilization treatment was used as a baseline measure for Bucket Two and the 'storage-shelf' condition.

The bacterial counts at the end of two weeks of storage under ambient conditions and anaerobic conditions confirm that the treatment did not successfully sterilize the product. Two obstacles would interfere with sterilization: the dry particle make-up of the product, protecting any bacteria in the interior of the particle and the spore stage of the endospore-forming bacteria, which is resistant to radiation and chemical treatment.

The 'sterilized' product stored under ambient shelf conditions had an increase in the total bacterial population (Tables 2c & 2d) from the Centridry product, ' un- sterilized'. There was a substantial increase in the total number of aerobic bacteria, as compared to the anaerobic population, consisting predominantly of a vegetative population (Tables 3c & 3d, 5 c & 5d). The ratio of aerobic spore-formers to anaerobic spore-formers was less in the stored product (Table 6b). There was a decrease in the ratio of mesophiles to thermophiles in the product stored for two weeks (Table 5b). However, overall, there did not appear to be a significant difference in the ratio of the mesophilic and thermophilic population.

The change in bacterial population characterized between the 'sterilized' Centridry product under ambient - shelf conditions and the Centridry product is predictable. The 'sterilization' treatment would kill exposed vegetative cells, and leave a population of protected spore- stage bacteria. Storing the 'sterilized' product under a less-stressful environmental condition, would allow the spores to ex-sporulate into vegetative forms and grow. The anaerobic vegetative cells present in the sample would not thrive in under ambient atmospheric conditions, and the anaerobic spore-forming bacteria would remain in spore stage.

The 'sterilized' product stored under anaerobic conditions had an increase in the total bacterial population at elevated incubation temperatures (Table 2c & 2d). The mesophilic portion of the bacterial population decreased over the two week test period (Tables 2c & 2d). The aerobic spore-forming portion of the population did not grow as well as the anaerobic spore-forming population (Tables 3c & 3d), and the total spore-forming population exceeded the vegetative portion (Tables 4c & 4d). The storage of the 'sterilized' product under anaerobic conditions influenced the distribution of the major bacterial groups under this test condition. There were a greater number of spores, resulting from the cidal effect of the treatment on the vegetative population. There was a greater proportion of anaerobes after storage under anaerobic conditions.

The cake solid was tested under two storage conditions: Cake solid stored under anaerobic conditions, and cake solid + product under anaerobic conditions.

Testing Condition Four, (Bucket Four), stored the Centridry product + dewatered cake solid (5:1), under anaerobic conditions. The combination of product and cake increased in total number of bacteria by providing a more suitable growth environment due to the increased water content. There was an increase in total bacterial numbers, in both the mesophilic and thermophilic populations. (Table 2g & 2h). Total spore-formers increased throughout the testing period, the percentage of spore-formers of the total bacterial population was near 100% (Table 2g & 2h). The spore-forming population was mesophilic and the vegetative population was thermophilic (Table 5d). The ratio of aerobic spore-formers to anaerobic spore-formers decreased, and the ratio of aerobic vegetative cells to anaerobic vegetative cells increased (Table 6d). It is difficult to tell what role the cake solid had in the reintroduction of microorganisms that may have been erradicated through the Centridry process. The total bacterial counts of this sample were similar to the final bacterial counts from the other bucket samples that did not contain cake solid in the bucket feed. The percentage of total spores in the cake solid was about the same as the Centridry product, and yet the bucket sample was 100% spore-formers. The mesophilic population of the cake solid was about the same as the Centridry product, and yet the bucket sample was predominantly thermophilic. The aerobic to anaerobic ratio of the cake solid and the Centridry product were nearly equal, yet, again, the bucket sample had over a two-hundred-fold increase in anaerobes as compared to aerobes (spore-formers) and a sixteen times greater increase of anaerobes to aerobes (vegetative cells). The data suggests that the cake solid improves the growth conditions of the bucket feed through the addition of water, or useable nutrients or some other physical condition.

Test Condition Five, (Bucket Five) contained cake solid stored under anaerobic conditions. The cake solid, as described above, has a greater water content than the Centridry product, that could contribute to a healthier environment for the bacteria. The total bacteria recovered under mesophilic conditions, decreased over the test period (Table 2i). The total bacteria recovered under thermophilic conditions increased over the test period (Table 2i). The mesophilic aerobic vegetative portion of the total bacterial count decreased, while the mesophilic spore-forming population increased. The thermophilic vegetative portion of the total bacterial count increased, while the thermophilic spore-forming population increased (Table 5e). The ratio of aerobic to anaerobic spore-formers increased over the testing time (Table 6e). The anaerobic environment did not seem to have an effect on the bacterial populations. There was a slight change in the proportion of mesophiles to thermopiles over the course of the testing period.

The end-products of the conventional wastewater treatment, cake solid, and the Centridry process, Centridry product, had very different bacterial population components. The cake solid had a greater ratio of aerobic vegetative bacteria than the Centridry product, and a smaller ratio of thermophilic anaerobic spore-formers. When these two products were stored for two weeks under anaerobic conditions, the population mirrored the bacterial composition of the products prior to storage.

Bacteria are able to survive and thrive in the most inhospitable environs, as demonstrated by this project. It is difficult to significantly impact the bacterial flora that naturally inhabit a given niche through simple environmental manipulations. This has been demonstrated by the work in the field of bioremediation. In all samples collected for the Odor Characterization study, bacteria multiplied, and metabolic activity occurred. The populations of bacteria recovered suggest a group of bacteria capable of metabolizing nutrients using pathways conducive to the production of intermediate- or end-product waste products that likely contribute to the odors produced under a variety of storage conditions. Further identification of the bacterial populations would contribute to our understanding of the relationship between specific bacterial populations and odor production.

TAB

F

APPENDIX F

CENTRIDRY™ MARKET RESEARCH REPORT FOR KING COUNTY DEPARTMENT OF NATURAL RESOURCES

NORTON
ARNOLD
& JANEWAY

Centridry Market Research Report
for
King County Department of Natural Resources

Norton-Arnold & Janeway

July 10, 1998

Table of Contents

Introduction

King County's Renton Wastewater Treatment Plant is experimenting with Centridry, a new type of biosolids product. Centridry has been available and used widely in Europe for a number of years. The chief feature of this centrifugal method of processing is the production of a biosolid that is 60% solids. The premise of the experimental program is that King County will be able to produce Centridry and offer it as a Class A compost product to biosolids customers located in western Washington.

Beginning in Spring 1998, two composting companies - Sawdust Supply, and Land Recovery, Inc. - entered into an agreement with the County to accept an initial shipment of the product and begin composting experiments. Using a variety of mixing materials and composting methods, the two companies are working to solve odor and dust problems inherent in the material. They hope to produce a final composted product that will be marketable to topsoil companies and the general public.

In June 1998, Norton-Arnold & Janeway conducted preliminary market research to determine the interest level in the topsoil business for this type of product. Using scripted topic guides, interviewers contacted a number of topsoil companies in King and Snohomish Counties. Full interviews were conducted with ten companies. In addition, representatives from both Sawdust Supply and Land Recovery, Inc., were interviewed as part of the research effort.

Results of this preliminary market research are promising for King County. There is significant interest in a product of this type, and a number of potential customers are willing to engage in a pilot effort with the County to experiment with the Centridry product.

As with any new set of customers, the County will need to work proactively to inform, encourage, and engage in market partnerships for the long term. Those interviewed provided a number of ideas on how the County could develop this market.

This report is divided into five sections. An Executive Summary provides highlights of the research results. Research Methodology describes the way the interviews were conducted. This is followed by the Key Findings from the interviews, as well as a set of recommendations on how the County can best develop this new market. The Appendix provides a detailed summary of each interview, as well as the topic guides used.

Executive Summary

The preliminary research conducted for King County's Centridry Pilot program consisted of telephone interviews with potential end-use customers. Two of these were composting companies currently experimenting with the Centridry product. Twenty-two were with topsoil companies identified from the U.S. West Yellow Pages. All are located in either King or Snohomish County.

The research was based on the premise that composting companies would use Centridry to produce a Class A composted product, which would then be sold to topsoil companies. Topsoil companies would use this composted Centridry product in the blends and soil mixes they offer to their customers. Two sets of interview questions were used for the two categories of interviews.

Key interview findings indicate there is interest in a biosolids product that is dryer than the products currently available. Topsoil companies are familiar with biosolids products and feel that they perform well. Eight companies requested further information on Centridry and, four of those expressed interest in working with the County on a pilot program for the product. This willingness is tempered, however, by interviewees' concern that there are negative public perceptions about the use of biosolids. Those interviewed are also concerned about odor control, dust, cost, and King County's ability to develop and maintain a long-term business relationship with them.

Based on suggestions from interviewees, as well as prior biosolids marketing experience, Norton-Arnold & Janeway recommends the following steps be taken to develop this new potential market:

- Conduct a significant public education campaign focused on the retail consumer.
- Address odor concerns.
- Provide support to distributors regarding health regulations.
- Publicize growth test results.
- Competitively price Centridry.
- Adopt best management practices protocol.
- Reassure the marketplace that the County is a good business partner.

Research Methodology

The preliminary research conducted for King County's Centridry Pilot program consisted of telephone interviews with potential end-use customers. Two of these were composting companies currently experimenting with the Centridry product. Twenty-two were with topsoil companies identified from the U.S. West Yellow Pages. All are located in either King or Snohomish County.

The research was based on the premise that composting companies would use Centridry to produce a Class A composted product, which would then be sold to topsoil companies. Topsoil companies would use this composted Centridry product in the blends and soil mixes they offer to their customers. Two sets of interview questions were used for the two categories of interviews.

Interviews with Topsoil Producers

All interviews were conducted by telephone between June 18 and June 29, 1998. Researchers identified themselves as calling on behalf of King County, and explained that the County is currently experimenting with some biosolids products that might be useful in the topsoil business. Interviewers explained that the purpose of the interview was to establish how topsoil companies make decisions about the products they offer to their customers.

Two attempts were made to contact each of the identified topsoil companies. In most cases, researchers left messages if the contact was unavailable. Two messages were left for each identified contact. If, after two attempts, the call was not returned or the phone was not answered, no further attempt was made to talk to the individual or the company. Of the twenty-two companies, three did not mix their own topsoil but sold a product developed elsewhere. These companies were not fully interviewed. By the end of the interview period, researchers were able to conduct full interviews with ten companies; one company had recently gone out of business; three companies never answered their phone; and the remaining five companies did not return calls. In most cases, the person interviewed either owned the business, was a general manager or soils production manager, or was a sales representative for the company.

A brief summary of each of the interviews conducted, as well as the topic guide used for the interviews, is included in the appendix of this report.

Interviews with Compost Producers

Two compost producers - Sawdust Supply in Seattle, and Land Resources, Inc. in Puyallup - are currently experimenting with the product generated by the Centridry pilot program which has been in operation since Spring 1998. Curly Winebrenner, from Sawdust Supply, and Jeff Gage, from LRI, were both interviewed on their experiences and future projections for continued work with the product. The topic guide for these interviews is included in the appendix of this report.

Key Findings

- **In general, positive reactions.**

  The results of the telephone interviews provide encouraging news for King County's Centridry program. The industry is clearly aware of biosolids and its use as a fertilizer. Of the twenty-two companies contacted, none had to have the term *biosolids* explained to them. Of the ten topsoil companies with whom a full interview was conducted, eight showed positive interest in Centridry, and four expressed a reasonable degree of interest in participating in a pilot program.

- **Familiarity increases comfort.**

  Conversations with the company representatives highlighted the fact that those who had prior experience working with biosolids had less hesitation about using them. Even within the same company, there was often a marked difference in attitude between the people in operations working with biosolids, such as soils production managers and owners, and the people answering the phones in the office.

- **Positive perceptions of performance.**

  Increased growth performance from use of the product was an accepted fact. There seemed no doubt on the part of topsoil companies that biosolids performed favorably. Those interviewed have clearly given thought to possible markets for Centridry, as well as other biosolids products. Those in the business of supplying growing materials recognize the increased growth performance of the products and feel that there is some market for them. It is their view, however, that the market could be limited by public perceptions of possible health issues.

- **Interest in a drier product.**

  Interviewees responded favorably to the concept of a biosolids product that is drier than those currently available. An issue mentioned regularly was the cost impact to a topsoil company of having to add large quantities of mixing material to the wetter biosolids in order to render them workable.

- **Optimism from the "tester" companies.**

  Additional good news for the Centridry program is that, after a several months of experimentation, both Sawdust Supply and Land Recovery, Inc., feel they have settled on a good mix for the compost product. The mixes are not identical – both the proportions and the mixing materials are different. It remains to be seen whether, in the final analysis, various successful mixes for optimum composting exist, or if composting companies will eventually settle on one universal mix. Though neither composting company has yet to perform growth tests using Centridry compost, both are equally optimistic about its anticipated performance and feel that markets exist for the product. Though an odor issue still exists in composting the product, both companies feel this problem can be somewhat mitigated by the type of material used in conjunction with the Centridry. Mixing and storage methods can also affect the amount of odor present.

- **A list of potential customers.**

  Following are the topsoil companies that expressed strong interest in working with the County on a pilot program for Centridry, provided that they receive additional information first, and that they are satisfied with the information provided. Full interview reports are included later in this report.

  Puget Sound Soils
  P. O. Box 1259
  Auburn, WA 98071
  253/833-0374 phone
  253/833-8418 fax
  Contact: Larry Martinson

  Red-E Topsoil
  18816 NE 80th
  Redmond, WA 98052
  425/868-6500 phone
  425/868-2218 fax
  Contact: Dale Scilley, Sales Department

  Renton Sand and Gravel
  P.O. Box 28
  Renton, WA 98057
  425/226-2255
  Contact: Mr. Buck, Owner

  Topsoils, Inc.
  18903 109th Avenue SE
  Snohomish, WA 98296
  425/485-0355
  Plant location:
  18827 Yew Way
  Snohomish, WA
  Contact: Dan McAuliffe

Development of the Centridry Market

Like any new potential customer base, customers for Centridry are not likely to come eagerly knocking on King County's door. County staff will need to work proactively to cultivate this new market. It is clear from the interviews that development of a Centridry market will require willingness on the part of the County to create strategic partnerships with potential new users. The partnerships should be designed to:

✓ Create an atmosphere of trust and collaboration with potential new customers.

✓ Address their concerns related to operations and product marketing.

✓ Create the kind of long-term relationship that leads to a continued, assured, marketplace for King County.

Interviewees said the following factors were key to their eventual long-term involvement with a Centridry product:

- **Conduct a significant public education campaign focused on the retail consumer.**

  Every interviewee commented on the negative public perception of biosolids products — some going so far as to say that, though they personally had no problem with using biosolids, they would not consider carrying any in their business simply because of negative public attitudes. In order to have composted Centridry available and accepted in the marketplace, the County needs to conduct a significant public education campaign focused on the retail consumer. The County must address concerns that the product could be a health hazard before businesses will feel comfortable getting involved with Centridry.

  In the marketplace some confusion exists about restrictions on the use of current biosolids products. Though GroCo is classified as a Class A product, interviewees stated that the package included restrictions on use in produce gardens. Both distributors and the retail consumer would be better served by having greater clarity on this topic.

- **Address odor concerns.**

  Odor is a major concern to topsoil companies. Their perception is that biosolids odors are distinct from other materials used in the industry, and topsoil companies worry that, because of the distinct odor, they will be penalized for using the product. In terms of Centridry, both Sawdust Supply and LRI continue to have serious concerns about the odor generated by the product. Both topsoil and composting companies voiced concerns that they will be cited for not adhering to current odor control regulations. This inhibits their desire to become involved with the material.

- **Provide support to distributors regarding health regulations.**

  All of the companies that expressed an interest in learning more about Centridry did so based on several contingencies. One is that they receive a full analysis of the product's content along with test summaries. Companies insist that the product meets all of the health regulations and that they are able to prove this to their customers. In addition, they ask that King County substantiate these health claims and provide support to distributors as they pass this information on to their customers. One interviewee asked: *Will the County be consistent? Or will one arm sell the product to me, and the other arm penalize me for using it?* Topsoil companies wanted to feel confident that the County would stand behind its product and those that sell it for them. Interviewees also wanted to avoid any liability for the product.

- **Publicize growth test results.**

  Prior to committing to a pilot program, topsoil companies want a complete set of statistics from the County on growth test results. They have a favorable expectation of what those results will be, but request full knowledge before becoming involved.

- **Competitively price Centridry.**

  Cost is a major concern to the topsoil companies. A strong selling point for Centridry compost material is that companies may not be required to spend as much money on filler to use the product. Most topsoil companies felt that, though there was some market for the product, it would not be as widely accepted as yardwaste or other compost products without biosolids. Therefore, it is important the County price the product with regard for limitations of the market. Make cost an incentive to use the product, not a hindrance.

- **Adopt best management practices protocol.**

  Topsoil companies did not want to spend time experimenting with Centridry to maximize its potential. They request information on successful mixing materials and proportions, recommendations for avoiding odor issues, suggested storage methods, and data on how the product reacts under certain conditions such as when it gets very wet. Companies would like to minimize time and financial risk by knowing as much as possible about the product prior to committing to use it.

- **Reassure the marketplace that the County is a good business partner.**

  Significant questions and concerns exist about the County's decision to market an additional product, as well as about its ability to be a good business partner. Interviewees said:

  We're battling public opinion in using a biosolids product. Can and will the County do the kind of public education campaign necessary for us to avoid financial risk with the product?

  Will the County stand behind its product when questions are raised about its safety?

  The County will be competing with "a ton" of products in this area. How much financial sense does it make for them to market this product and how aggressively can they do it given the bureaucracy?

  Why is the County competing against itself with Centridry versus GroCo?

Appendix

Interview Topic Guides
Summary of Interviews

Topic Guide for Topsoil Companies

A. **Business Background**

1. First, I'd like to ask you a few questions about your business. I know you are a topsoil producer – but how many types of products do you offer to your customers?
2. Approximately how much topsoil do you estimate that you sell on an annual basis?
3. Are your customers primary wholesale or retail (e.g. landscape contractors vs. homeowners, etc.)?

B. **Biosolids Familiarity**

1. How familiar are you with biosolids – the solids produced after wastewater treatment?
2. Have you heard about – or do you have familiarity with biosolids based on the King County (Metro) product, or is your knowledge of biosolids based on experience elsewhere?
3. **IF KNOWLEDGE OF KING COUNTY BIOSOLIDS:** What do you know about King County biosolids?
4. Have you ever considered using biosolids or a composted biosolids product as one of the components in the soil mixes you offer your customers?
5. **IF INTERVIEWEE HAS EXPERIENCE WITH OR KNOWLEDGE OF BIOSOLIDS:** What was your experience with a biosolids product? Are you continuing to use it? Why or why not?
6. **If INTERVIEWEE HAS NEVER USED BIOSOLIDS OR HAS NO KNOWLEDGE OF THEM:** Why haven't you used biosolids? What is your perception of them in general? (Probe for whether there has been a past negative experience, or if there is simply no knowledge of biosolids.)

C. **Centridry**

King County's latest biosolids product is called Centridry. It is a relatively dry product (60% solids), which makes it significantly drier than some of the other products that you may have seen from King County/Metro. It has an ammonia nitrogen content of .9 – 1.2% and an organic nitrogen content of 1.9 – 2.8%.

1. Does this sound like the kind of product that might be of interest to you as you consider a variety of topsoil mixes? Why or why not?
2. **IF OF INTEREST:** What other information would you need to have about Centridry before you could make a decision on whether or not to use it in one of your products?
3. **ASK THIS QUESTION IF THEY ARE VERY INTERESTED IN CONTINUING TO DISCUSS CENTRIDRY:** Based on what you

have heard about Centridry, can you make any guesses about the fraction of Centridry product you might incorporate into a final topsoil product?

D. Possible Partnership

1. How could King County be most helpful to you in making this decision? Do you like to see the product in action (for example, a demonstration garden?). Could we deliver some material for you to test on a pilot basis? What facts and figures are of most use to you, and what is the best way to get that information to you?
2. Would you be interested in working with King County on a pilot basis with the Centridry material? If so, when would be the best time of year to do this testing with you?

Topic Guide for Composting Companies

1. How have you used the Centridry material in your composting operations? What other materials have you mixed it with?
2. How well does the Centridry product mix with these other materials? Is the mix you are currently producing one that you believe you will stick with?
3. Have you had any growing experience yet with the compost product you have produced with Centridry? If so, how well does the product perform? If not, what are your expectations for the product?
4. How does the Centridry material handle for you? Any dust, odors, or other difficulties to report? If so, what are they?
5. What kinds of advantages do you think Centridry provides to your compost products?
6. Is this an advantage you believe you will be able to actively market to your customers in the future?
7. Would you like to continue to receive Centridry material from King County? Is it a product you intend to continue to use? Why or why not?
8. **IF YES:** If you do want to continue to use Centridry, what kinds of volumes would you need on an annual basis from King County in order to maintain a viable Centridry product line?
9. **IF NO:** What do you think are the most significant barriers to your continued use of Centridry? Is there any way to surmount these current difficulties? If yes, what kinds of things would need to be done to make the product more viable, in your view, over the long term?

Interview Summaries
Topsoil Companies

Alpine Topsoils
Bothell
425/806-5100

No answer.

Bud's Topsoils
1733 120th NE
Bellevue, WA 98005
425/454-2900

Debbie, the office manager, was interviewed by phone on 6/18/98. Bud's Topsoils receives soil from job sites and adds yardwaste to it. They offer their customers Cedar Grove compost from Maple Valley, fine bark, medium fine bark, and a 5-way topsoil that they make themselves. The company sells about $100,000 of topsoil per year. Approximately half of their volume is sold wholesale to landscapers and the other half is sold retail to homeowners. Debbie has been with Bud's Topsoils for seven months. She has no knowledge of biosolids other than a familiarity with the term *sludge* and the product name GroCo. As far as she knows, the company has never considered using biosolids. The company is currently in the process of being sold and having its property taken over by a new interest. Therefore, they are not a candidate for using Centridry.

Burien Bark Supply
13400 1st Ave S.
Burien, WA 98168
206/242-6567

Spoke by phone with Bob on 6/18/98. Burien Bark Supply doesn't do any mixing themselves but gets all their material from Lloyd's Sand and Gravel in Federal Way. He referred the interviewer to them.

Burien Sand and Gravel
206/242-1161

No answer.

CAD Company
425/277-1014

No answer.

Carpinito Brothers
1148 N. Central Ave.
Kent, WA 98032
206/623-8103

Upon calling Carpinito Brothers, the interviewer was told by the receptionist, *We never use that stuff. From my experience, people won't use it. They say, 'I don't want anything with that human stuff in it!'* The interviewer left a message for Dan, the owner, to return her call.

On 6/22/98, Mike, Dan's brother, returned the call. Carpinito Brothers produces three kinds of potting soil, one kind of topsoil, and are wholesale brokers for peat moss. The company sells bagged products in addition to bulk loads. According to Mike, they are the biggest 'bagger' in Western Washington. They sell *many, many, thousands of cubic yards annually.* The business is primarily retail; they do a U-haul trade in addition to working with commercial landscapers.

Mike is somewhat familiar with biosolids and GroCo from Sawdust Supply. He was not aware that King County had a product but knew the Metro product. He has some knowledge of a similar program in Pierce County. His concerns were:

1. Restrictions on use of the product. Mike thought that there were restrictions on the use of GroCo and that it was not approved for use on vegetable gardens. He said that it made no sense for them to use a product that had restrictions since people buy topsoil for all uses, not specific ones.
2. Battling public opinion on use of the product. *King County would have to do a massive public education campaign before our customers would use it.*
3. Mike said that the GroCo product made no sense for them to use directly from the County since Carpinito Brothers doesn't have composting facilities and the product would have to be composted and have filler added before they could use it. The fact that Centridry would arrive in a composted form and was a drier product than previously available from the County was a positive feature for him.

Given a satisfactory response to three issues listed above, Carpinito Brothers would consider using Centridry. However, listed below are Mike's personal and professional feelings about this endeavor of the County's:

- Why is the County going to compete directly with its yardwaste compost program? Given a choice, people will prefer yardwaste to human waste.
- Can the County do an adequate job of educating the public? This is a massive undertaking. Wouldn't the County's resources be better placed elsewhere where they have an opportunity for success?
- The County will be competing with *a ton of products* in this area. There is a lot of competition and certainly not room for all products. *The County*

can't do anything cheaply and this type of product marketing will not benefit from a bureaucratic approach. The finances of the County would be better served by minimizing, rather than maximizing, its involvement in the composting business. Why not simply keep the biosolids in their natural form and license others to take on the process from there? The best application for biosolids would be to the national and private forests rather than agriculturally. In addition, the County should take advantage of the growing ornamental nursery business in Western Washington and market to them. In other words, target easier markets than the market for urban topsoil use.

Mike would like to receive specific information on:

1. The restrictions for use with GroCo and Centridry, as well as any additional information on the Centridry product – though this does not mean he is volunteering to be involved.
2. Cascade Northwest's experience (in Puyallup) with the biosolids experiment and the reason why they quit the program.

Harry's Topsoil
425/485-1521

Did not return calls.

Iddings, Inc.
27525 Covington Way SE
Kent, WA
253-630-0600 or 253/631-2290

Did not return calls.

Issaquah Sand & Gravel
P.O. Box 787
Issaquah, WA 98027
425/392-8336

They buy all of their materials from Cedar Grove Composting and do no mixing themselves. They suggested that the interviewer talk to Cedar Grove.

Jim's Landscape Supplies
28945 229th Place SE
Kent, WA
253-639-2200

Did not return calls.

Lloyd's Sand and Gravel
P.O. Box 3889
Federal Way, WA 98003
253/874-6692

Greg Miller, Soils Production Manager, was interviewed on 6/18/98. Lloyd's Sand and Gravel offers approximately 6 different blends of topsoil to their customers using organic material, composting, sand, sawdust, etc. The company sells about 100,000 cubic yards annually. They often work with architects and mix topsoil to meet the architects' specifications. Overall, business volume is evenly divided between wholesale and retail. Greg has heard of and worked with biosolids before, through Pierce County's Tagro program. Though he has worked with GroCo from Sawdust Supply, he was not aware that King County had a biosolids product. Lloyd's uses green waste at this time. They are happy with their current product line. They are not doing their own composting. According to Greg, their final topsoil product uses a maximum of 25 - 30% additives; they feel that any more than this is detrimental to the soil. Therefore, should they introduce Centridry into their line, it would be included as a portion of that total additive amount.

In Greg's experience, biosolids products worked great: *They grew huge tomatoes*. However, he is leery of the product because of *where it comes from*. He specifically mentioned his concern with heavy metals in the product. When asked if Centridry was a product that would be of interest to him, he replied that it would depend on several factors. First, the cost of the product would be an important issue to the company as it considered the product. In past experience, other biosolids products were so wet that the company had to spend a considerable sum of money on sawdust or some other agent to get the material dry enough to work with. Therefore, the drier Centridry product would be a definite advantage over the previous biosolids products. A second major consideration is the health issue associated with the use of biosolids. Before using them, Greg would like to have an environmental disclaimer from the County.

Greg was somewhat interested in receiving additional materials about Centridry. He didn't say that he was interested in being part of a test program; but he *did* say that, if he were to test Centridry, he would want to do it in the spring when his volumes are high.

Pacific Topsoils, Inc
1-800-884-SOIL

Did not return calls.

Plant Food Company
14415 35th Ave SE
Bothell, WA
425/743-2163

No longer selling topsoil.

Plant Mulch Company
P.O. Box 982
Snohomish, WA 98291
425/483-9200

Ivan Johnson, President, reported that Plant Mulch Company offers six or seven blends of topsoil. Ivan said it is not possible for him to give an estimate of their annual sales since the number varies widely from year to year. They have both wholesale and retail customers. Eighty percent of their sales are retail; the remainder is wholesale.

Ivan's only experience with biosolids was four or five years ago when a contractor wanted to use a topsoil with biosolids in it on a public project in Snohomish and the city was not in favor of it. He also has customers regularly ask whether *there is any of that human stuff* in the topsoil they are ordering. Ivan, personally, would not be opposed to using Centridry if it were tested and proven completely safe. However, he would only consider using it in his business after the County had conducted an extensive public education campaign so that he would not run up against negative attitudes toward its use.

Puget Sound Soils
P. O. Box 1259
Auburn, WA 98071
253/833-0374 phone
253/833-8418 fax

Larry Martinson was eager to be interviewed. Puget Sound Soils is three years old. They have two types of topsoil to offer, but are known, according to Larry, as a specialty company with experience in such projects as soccer fields, rooftop gardens, and many public venues. They do a lot of work to the specifications of landscape architects. Larry estimated that the company sells approximately 18,000 – 20,000 cubic yards annually. Their topsoil customers are about 50/50 wholesale and retail.

Larry is familiar with biosolids from the Nutri-Mulch product at Northwest Cascade, which he identified as a Pierce County product. His major experience working with biosolids was at the Emerald Downs Racetrack. On that particular project, the project manager insisted on using biosolids. Larry has considered using biosolids at Puget Sound Soils. He thinks that it's a great product and really works well but says ... *that it gives him and his workers the 'willies.'* He has just started using compost from Soos Creek Organics in Covington.

Larry said he would consider using Centridry and being part of a pilot program. However, he would need satisfactory answers to the following concerns before committing to participate:

1. What is the cost of the product? Cost was cited as being a major factor in the decision-making process.
2. What is the content analysis of the product? Larry is concerned about the origin of the material, health issues, and customer attitudes toward the product. He felt he would need to be able to put his customers' concerns to rest before he could agree to use the product.

<u>**Red-E Topsoil**</u>
18816 NE 80th
Redmond, WA 98052
425/868-6500 phone
425/868-2218 fax

On 6/23/98 an interview was conducted with Dale Scilley in the Sales Department. Red-E Topsoil sells various groundcovers such as rock and bark, as well as approximately nine varieties of topsoil including blends, composted, sand, etc. Their sales are about 50,000 to 60,000 cubic yards annually with a wholesale/retail breakdown of about 70/30. Dale is familiar with GroCo, which they obtain from Sawdust Supply. However, Dan referred to GroCo as a Metro product, rather than a King County product. Sawdust Supply and Red-E work closely together. They exchange other materials in addition to the GroCo. Dale characterized Red-E Topsoils experience with GroCo as a positive one. About 90% of the GroCo they use is sold as a top dress; the remaining 10% is mixed in with blends. Dale felt that the company would use more GroCo if it cost less.

Dale felt that Centridry sounded like a product that they would be interested in using. Normally, 20% is the limit to what they incorporate into a final topsoil product. However, they would need to have the following questions satisfactorily answered:

1. What is the cost?
2. What is the consistency like? Is it fine? Is dust an issue?
3. What is the odor issue with it? What about odor wet versus odor under dry conditions?
4. Red-E Topsoil does not have bunkers available for storage. What happens when the Centridry gets wet? How much water can it hold? Does it get sloppy and runny? When it dries out, can it still be used?

5. What restrictions are there on use? The quantity of use is affected by restrictions. (Though GroCo has no restrictions on its use according to Bob Bucher, Dale said that the bags of GroCo have disclaimers on them for using on edibles.)
6. What is the analysis of the contents, especially the heavy metals?

If the above questions were answered satisfactorily, Red-E Topsoil would consider working with King County on a pilot basis for Centridry. One last note, Dale found it interesting that the County would compete against itself and GroCo from the West Point Plant – a point that came up during several interviews.

Renton Sand and Gravel
P.O. Box 28
Renton, WA 98057
Plant location:
627 SW 12th
Renton, WA
425/226-2255

Mr. Buck, the owner, was interviewed on 6/24/98. Up until about a year ago, Renton Sand and Gravel was located across from the Renton Wastewater Treatment Plant. Mr. Buck is quite familiar with the Renton operation and has supplied soil to them for various projects. In the past, the company's biggest year had sales of 30,000 cubic yards of topsoil. However, as the current, temporary location is significantly smaller than the previous location, the volume of business has significantly dropped. Due to location restraints, Renton Sand & Gravel is producing only one kind of topsoil. Mr. Buck is in the process of looking for larger, permanent space for his business. In the past, typical clients have been Emerald Downs Racetrack, King County Parks and Recreation, King County Airport, and South Seattle Community College. Mr. Buck estimates that his business is evenly divided between wholesale and retail sales.

In previous years, Renton Sand and Gravel has worked with GroCo through Sawdust Supply. It was not used as a mixture or additive in their blended topsoil, but supplied as a special order at the request of landscape architects. Mr. Buck is interested in working with the County in a pilot program for the product, provided he can find a suitable, permanent location for his business. Given a satisfactory resolution to the location issue, he would require:

1. complete information on the safety and health issues associated with the use of biosolids,
2. full back-up and support from the County in response to issues raised by the public over use of the material, and
3. a satisfactory experience working with the Centridry as it is mixed with other materials.

Ultimately, Mr. Buck would like to be able to offer two topsoil blends to his customers – one with Centridry and one without.

Sayers Fuel
3809 Rainier So.
Seattle, WA 98118
206/723-0564

They buy all of their topsoil pre-mixed from Red-E Topsoil and Pacific Topsoils.

Sky Nursery
18528 Aurora Ave N.
Shoreline, WA 98133
206/546-4851

On 6/23/98, the interviewer spoke briefly to Linda, one of the owners. Ron, Linda's brother, is in charge of the soils. Since Ron was not available, Linda offered to be interviewed.

Sky Nursery is a retail business. Their soils sales from compost, gravel, bulk, etc., comprise about 25% of their business. They give discounts for large quantities. Four or five years ago the nursery used GroCo. They thought it was a great product but stopped using it because a couple of their customers were very upset about the origins of the product and the possibility of heavy metals in it. Not all customers were upset – only a few very vocal ones. Linda said that the nursery is always interested in receiving information about new products. However, public opinion will play an important role in whether or not the nursery will ever carry a biosolids product again in the future.

Sposari's Landscaping & Materials
9255 16th Avenue SW
Seattle, WA 98106
206/762-2236

Bill, the manager, was interviewed on 6/23/98. Sposari's has both wholesale and retail customers. They buy all of their topsoil from other producers. Pacific Topsoils is one of their suppliers. Bill is familiar with biosolids through GroCo. However, his company uses only steer manure and *other natural products*. They do not use GroCo because, *They use chemicals to treat the stuff and people get rashes from it if they don't use rubber gloves when they touch it.* He is not interested in using any other biosolids product because of the chemical processing. In addition, he does not have any additional bins for other products.

Sunset Materials
18011 SE Renton-Issaquah Road
Renton, WA
425/226-4140

Did not return calls.

Topsoils, Inc.
18903 109th Avenue SE
Snohomish, WA 98296
425/485-0355
Plant location:
18827 Yew Way
Snohomish, WA

The interviewer spoke with Dan McAuliffe, owner and operator. His operation offers about six different varieties of topsoil. Although they have some wholesale business, the majority of the business is retail. On an annual basis, they sell approximately 10,000 cubic yards of topsoil.

Dan says he is *pretty familiar* with biosolids. He is the previous owner of Pacific Topsoils and used biosolids there. In his current business, he uses steer manure and no biosolids. He has no real experience working with a King County product. He is not personally opposed to working with the product. However, his two main concerns are cost and health issues. In his business, people pay him when dropping off their dirt, lumber, etc.; he processes this material in some fashion, and then resells it. Dan characterized the process: *People pay to drop it off, and pay again to take it away.* Anything that he has to pay for in the middle of that process diminishes his return. Secondly, Dan is concerned about the health issues with using Centridry. Before using biosolids, he would require full information from the County that the product has passed all regulations and that there are absolutely no health issues associated with the product. In addition to the issues stated above, Dan is concerned that ... *one arm of the County would convince me to use the product, and another arm of the County would penalize me for being involved with the substance.* He would like reassurance that there is consistency in the County for use of the product.

If the concerns mentioned above are satisfied, Dan is inclined to participate and to work with the County on a pilot basis.

NOTE: At this time, Dan would like to receive any analysis available of the product's content and all information that the County may have on the most beneficial mixes and blends. The interviewer told him that she would pass his name, address, and requests for information on to those in charge of the program.

Interview Summaries
Compost Producers

Sawdust Supply
15 S. Spokane
Seattle, WA 98134
206/622-4321

On June 25, 1998, Curly Winebrenner of Sawdust Supply was interviewed as one of the participants in the pilot composting program. Sawdust Supply has been involved with the Centridry composting pilot since early spring of 1998. They have been experimenting with three mixes of composting material and Centridry:

- 2 parts sawdust (fir, hemlock), 1 part Centridry
- 3 parts sawdust, 1 part Centridry
- 3 parts sawdust, 1 part Centridry, 20% biosolids

Though still in the experimental stage with the product, Curly believes that their mix proportions are reasonable; however, they are having a problem with the method used to mix the materials. Due to the dryness of the Centridry product, the dust raised in their traditional method of mixing is not acceptable. The company has decided to convert to an auger-type of mixing, which they feel will work better with this product. Curly stated that it is obvious to them that the company needs to solve the dryness problem with different mixing methods before they can move forward.

In addition to dust, odor has proven to be a major issue. The first time the compost piles were turned, *there was a horrendous odor, like rotting flesh*. According to Mr. Winebrenner, it was an unforgettable experience for everyone involved. The company is planning to turn the piles again in the near future but, reviewing test results taken since the first time the compost was turned, they anticipate that the odor will not be as bad on the second turning.

Sawdust Supply is still working on the composting methods and therefore has not yet had any growing experience with the Centridry compost. It will most likely be late winter before they have a full picture of the product, including preferred composting, mixing, and growth opportunities. At this point, their experience leads them to believe that the 2 parts sawdust/1 part Centridry mix is the most difficult to handle but the best-looking product since it closely resembles dirt. Growth tests expected in the late fall will provide more information.

The company is considering the advantages Centridry provides to their compost products. They have carried GroCo as a product since 1976 and feel their customers are used to it and like the fact that the texture is predictable and familiar. Previously, when Sawdust Supply tried to offer a product composed of yardwaste with biosolids, they had *a rebellion on our hands over the change in texture.*

In Curly's view, the Centridry composted material could be extremely nice for a potting soil. He feels that it would make a good premium product or a bagged product. He added that once the product goes through the entire composting cycle, Sawdust Supply will know better what they have and what they can do with it. Whether or not the product has an advantage that the company will be able to actively market to possible future customers remains to be seen, but they believe that with an aggressive marketing campaign, the best use may be as a premium product. That will limit the amount they can sell, but is likely to command a higher price in the marketplace.

There are many contingencies that currently prevent Sawdust Supply from determining if Centridry is a product they intend to use. Curly assessed their current status as such:

> *First of all, we have to deal with the mixing issue. Secondly, we haven't yet seen how it does with fertility, and finally, the odor issue is a really big problem. When you get even one call on odor it opens the door to a whole new raft of problems. Everyone becomes involved then. Look at Northwest Cascade; odors are what put them out of business. Cedar Grove had a big problem there too. So, before we can really go forward with knowing if we are going to keep using the product, we need to see if we can solve some of these problems and actually see how the stuff performs in growth testing. The growth tests will take three or four months, so we should have a better idea in late winter of this year.*

<u>**Land Recovery Inc.**</u>

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Puyallup, WA 98373
(253) 847-7555

On June 30, 1998, Jeff Gage, Director of Recycling, was interviewed. LRI has been involved with the Centridry composting program since early Spring 1998. At that time, they received two truckloads of the material. LRI has been experimenting with three different compost mixes using Centridry. Using proportions by volume rather than weight, the three mixes are as follows:

- 4 parts yardwaste, 1 part Centridry
- 2 parts yardwaste, 1 part Centridry
- 3 parts fir sawdust, 1 part Centridry

Jeff feels that the mixes are well-proportioned and that using a screw auger blender in the mixing process, as well as maintaining high levels of moisture in the mix, helped to eliminate some of the dust issues mentioned by Curly Winebrenner. He also feels that the 4/1 mix is their most successful. Experiments at LRI have shown that the addition of yardwaste to the compost improves the texture and the odor of the final product. In addition, the interaction of yardwaste and Centridry in composting creates a higher clay content in the material, which should improve the water-holding capacity of the soil. Jeff commented that the substance sticks to one's hand somewhat like glue. The remaining general characteristics, beyond the clay texture, are dirt-like. However, the product retains a slight, characteristic, biosolids odor.

The 3/1 mix using sawdust also worked positively; however, the odor from the sawdust prevents them from continuing to work with this blend. The composting process is being carried out in fully enclosed boxes using a blower system for adding and removing air from the compost boxes. These odor control mechanisms are proving to be successful for them. Jeff noted that when the Centridry was delivered to LRI, comments from the transfer station operators about the odor were *significant* and *poor*. The staff was emphatic in stating that the odor was strikingly different from that of the yardwaste to which they were accustomed.

LRI has not yet had any experience with using the compost in growth experiments. At this time, they are still working out inconsistencies with their lab results. However, their expectations for results from growth experiments are high, as they feel that the Centridry compost will improve both the nitrogen and nutrient contents of the soil. However, a major question for the company is whether the growth performance of the product will outweigh the negative perceptual attitudes in the retail market stemming from the origin of the product. In Jeff's opinion, the best marketing strategy is to develop a grade of product focused on contractor use. Though compost made of yardwaste does not perform as well as that made of biosolids, LRI intends to market the more accepted yardwaste at a higher charge than the better-performing biosolids compost products.

Another obstacle for LRI is uncertainty over the direction the State of Washington will take in its current debate on the topic of waste fertilizer, levels of acceptability for metals, and application levels for the products. If major restrictions are put into place as a result of these debates, LRI feels that its ability to market a compost product using Centridry may be limited. If regulations stay as they are currently written, LRI anticipates that they could use between 20 and 32 wet tons per day of Centridry.

TAB

G

APPENDIX G

FEASIBILITY ANALYSIS--
PLACING CENTRIDRY™ UNITS IN EXISTING STRUCTURE

MEMORANDUM

96-005

SYMONDS

CONSULTING ENGINEERS

Date: October 1, 1998

To: Gary Newman
Brown and Caldwell

From: Charles I. Dinsmore P.E.
Symonds Consulting Engineers, Inc.

Re: *Renton Treatment Plant*
Feasibility Assessment-Placing Centridry Units on Existing Structure

INTRODUCTION

Symonds Consulting Engineers has been requested by Brown and Caldwell to determine the feasibility of placing three Centridry units on the existing floor structure in the Sludge Dewatering Building at the Renton Treatment Plant. The task is to analyze the existing concrete floor structure for its capacity to support the new loading and assess the effect of vibration, also, to review the existing structure for lateral force resistance.

DESCRIPTION OF THE EXISTING STRUCTURE

The existing floor structure where the Centridry units are to be located consists of a ten inch concrete slab that spans between concrete encased composite steel beams that span 37 feet. The composite beams are composed of W24X104 steel sections with an encasement of concrete measuring 18"X32" with some mild reinforcing. The steel beams are connected to steel columns. From the existing drawings the beams appear to have shear plate connections which indicate that the beams were designed to be simply supported. The columns continue vertically to support the roof structure. The concrete used for the existing structure had a 28 day strength of 4,000 psi and the reinforcing used was grade 40 with a yield strength of 40,000 psi. The structural steel is ASTM A-36 with a yield strength of 36,000 psi.

LATERAL FORCE SYSTEM OF THE EXISTING STRUCTURE

A review of the existing drawings was made to determine the lateral force resisting system of the structure. The entire building consists of two parts, the original building that was designed in 1984 and an addition designed in 1993.
It is assumed that the original building was designed to meet the requirements of the 1982 Uniform Building Code (UBC) and the addition was designed to meet the requirements of the 1991 UBC.

We have determined that the lateral force system of the original building was a combination of moment resisting steel frames and concrete shear walls. The lateral forces are distributed to the resisting elements by a rigid concrete floor diaphragm. The drawings indicate the building was designed and detailed properly. The lateral resisting system of the addition consists of moment frames and shear walls similar to the original building. More shear walls were added in the addition and the detailing appears to tie the addition to the existing structure. These new elements added lateral strength to the original structure. A more detailed analysis than this scope will allow would be necessary to determine whether the tie is adequate to transfer seismic shear forces.

In our opinion the building has substantial seismic force resisting capacity and any reinforcement required by increased loading due to the Centriday equipment would be minimal. However, codes have changed since this building was constructed particularly with respect to seismic criteria and detailing. The level of seismic reinforcing required could be dependent on the level of seismic upgrade specified by the local building official.

We contacted the City of Renton Building department to find out what they would require. The scope of the project was described. The possible structural modification due to the addition of the new Centridry equipment and a seismic upgrade was included in the discussion. The opinion of the building official was that a complete code upgrade would not be necessary if only strengthening of the elements along the present load path is required. A FEMA type of analysis would be adequate to determine where the structure elements that need to be strengthened are located. The addition of the Centridry equipment and supporting structure would have to follow the 1997 Uniform Building Code requirements.

ANALYSIS CRITERIA

The analysis of the existing floor structure was based on the criteria contained in the ACI-350, 'Concrete Sanitary Engineering Structures'. To determine the capacity of the beams the Allowable Stress Method was used for calculating the properties of the composite section. The concrete portion of the beam section was reduced using the value of 'n' which is the ratio of the elastic modulus of steel to that of concrete. The final section properties assumed that a cracked section develops due to the loading. These properties were used when calculating the deflection to determine the natural frequency of the beam. Section 2.9 was used to determine a basis for vibration. To minimize resonant vibrations the ratio of the natural frequency of the structure to the frequency of the disturbing force should be kept out of the range from .5 to 1.5. The method described in this section was used to estimate the vibration effect on the structure by adding the three Centridry units.

EQUIPMENT DESCRIPTION

Three Centridry CD 3074 machines are to be placed on a platform that sits on the existing floor structure. The given weight for each machine is estimated to be 29,500 lbs. The vibration data given for each unit was 2750 RPM (considered cycles per minute) for the operating speed. The dynamic forces produced by the machines on four support points were in the range of 260 lbf to 313 lbf for vertical direction and 105 lbf to 125 lbf in the horizontal direction.
In addition to the Centridry units other related equipment will be placed on the remaining portion of the slab structure. The beams and slab need to have the capacity for these loads also.

EQUIPMENT PLACEMENT AND LOAD DISTRIBUTION

A drawing was supplied showing how the machines will be installed in the existing structure. A section on the drawing indicates the machines will be placed on a platform that is 3m (10 feet) above the existing floor level. A plan layout was on the same drawing showing the horizontal locations on the platform. To analyze the existing structure assumptions had to be made for the supporting platform. It was assumed the platform would be constructed of structural steel members with a steel grating floor. Steel columns were located on the existing composite beams rather than placing them on the concrete slab. The dead, live and machine loads were then distributed to the steel columns with an estimated framing layout. It is these loads that are used to verify the capacity of the existing composite beams. Other equipment is placed directly on the concrete slab.

SUMMARY OF ANALYSIS AND FINDINGS

Calculations were performed to find the capacity of the existing composite beam and verify its capability to support the added loads. A dead load was assumed for the new platform. A 50 psf live load and the weight of the machine was applied. The loads were distributed to the assumed platform columns and placed on the existing composite beams. No live load was placed on the existing floor structure in order to determine what live load capacity would be available after the new loads are added. The calculations indicate that the existing beams can support the new loads but a maximum live load that can be placed on the existing floor structure is 60 psf. As noted on the drawings the original design live load for the area was 150 psf. Calculations were performed for the ten inch concrete slab to determine the original design load and what capacity is available to support the other equipment that is needed for the Centridry units. The slab was found to be designed for a capacity of 250 psf. This value was obtained considering the slab to be simply supported rather than continuous over several beam supports. If the slab is considered to be continuous the calculations indicate that the maximum live load capacity is 129 psf. The maximum operating weight of 12,500 lbs is required to be placed on the slab for one unit of additional equipment. The amount of area required to bring the loading to 129 psf would be 97 square feet. If the footprint of the unit distributes the weight in less area a steel plate or other means of distributing the weight would be required. The specifications for the unit mentioned above state a worse case weight of 43,500 lbs could be obtained.
This weight would exceed the limitations of the existing slab and beams and additional reinforcement would be required for the floor structure.

The dead load on the assumed platform, the machine load, the dead load on the existing beam and floor slab were used to calculate the immediate deflection. The immediate deflection is used to find the natural frequency of the beam as part of the floor structure. The formulas described in the ACI-350 section 2.9 and table 2.9.2a are used to determine a natural frequency. Solving the formula with the immediate deflection that was calculated gives a natural frequency of 275 cycles per minute. The ratio of natural frequency to operating speed results in a value of .1 which less than the low end of the range mentioned above.

This method is ordinarily used when a forcing element is placed directly on a structure. The Centridry units here are being supported by a steel framed platform ten feet above the existing floor. The frequency of the steel frame support members is of primary importance and should be designed to transfer vibration within the same range as the existing structure.

RECOMMENDATIONS

With the calculated live load capacity available for the floor structure at 60 psf we would recommend a posted value for live load not greater than 50 psf with the Centridry machines installed on the new platform. If a larger live load capacity is desired, and the worst case weight for the additional equipment reaches the indicated values structural modifications to the existing structure will be required for added strength.

When the frequency ratio is less than .5, the machine would pass through the critical cycle at startup and shutdown. ACI recommends maintaining a ratio above 1.5. If this is desired structural modifications will be required to the existing structure.

For vibration control the new platform should be dynamically designed to accommodate the vibrations from the machines and to distribute the loads to the existing composite beams rather then the slab structure. When a platform structure is designed, a more accurate determination of how the machine vibration will effect the existing floor structure.

If deemed necessary by further analysis additional reinforcing to completely tie the structure of the addition designed in 1993 to the original structure for lateral forces.

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SYMONDS
CONSULTING ENGINEERS
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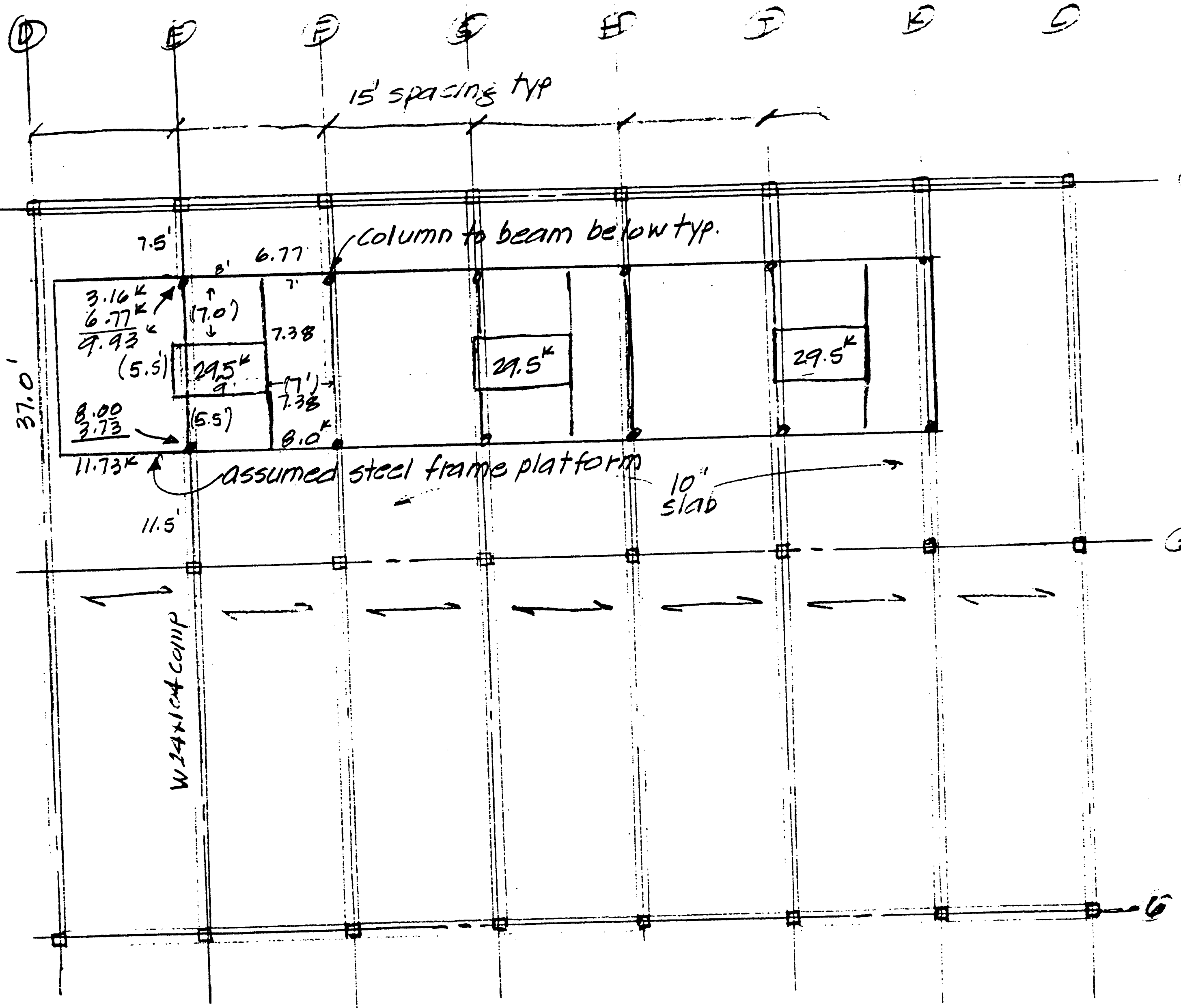
Project	Centridry For Renton Treatment Plt.	Job No.	96005	Page	of
Client	Brown and Caldwell	By	CID	Date	7/28/98
Subject	Feasibility Study	Checked		Date	



FLOOR PLAN

Existing Structure

SYMONDS
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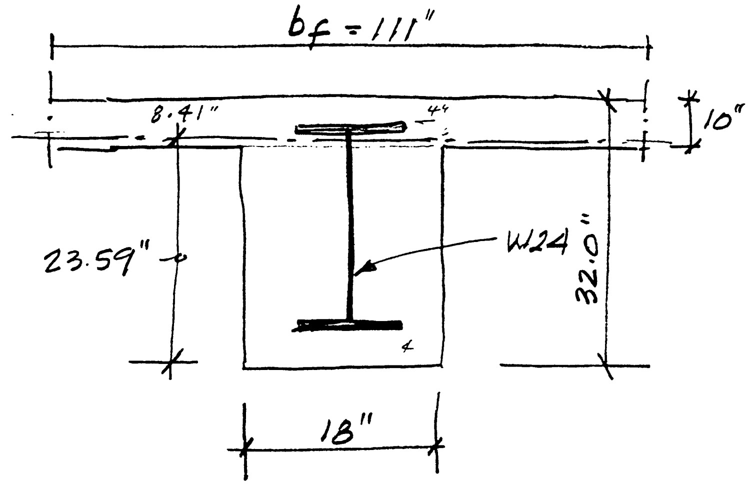
Project: Renton Treatment Plant | Job No. 96005 | Page 1 of
Client: Brown and Caldwell | By CJD | Date 7/28/98
Subject: Centridry Equipment Study | Checked | Date

Feasibility Study
ACI-350 criteria For Sanitary Structures

Existing Structure -
Encased composite steel beams w/10" concrete floor slab
Concrete $f_c' = 4000$ psi steel reinf $F_y = 40$ ksi.
Beam spacing at 15'-0" Span L = 37'-0"
Steel Properties ASTM A-36 $F_y = 36$ ksi
Steel beam W24 x 104 concrete section 18" x 32"

$A = 30.6\ in^2$ $E_c = 3{,}600$ ksi
$S_x = 258\ in^3$ $E_s = 29{,}000$ ksi
$S_y = 40.7\ in^3$ $n = 8$ $f_c = 0.45(4000) = 1800$ psi
$I_x = 3100\ in^4$
$I_y = 259\ in^4$



Properties of Section

$L/4 = \frac{37(12)}{4} = 111"$ ← governs
$b_w = 18 + 16(10) = 178"$
$b = 15(12) = 180"$

Beam dead load
$\frac{10(15)(12)}{144}(0.15) = 1.88\ k/'$
$\frac{22(18) - 30.6}{144}(0.15) = 0.381\ k/'$
beam $+0.104\ k/'$
Dead load $2.37\ k/'$

Properties of Section
locate Centroid

$A = \frac{10(111)}{8} = 138\ in^2$
stem $\frac{18(22)}{8} - 30.6 = 18.9\ in^2$
steel $= 30.6\ in^2$

$y = \frac{138(27) + 18.9(11) + 30.6(16)}{138 + 18.9 + 30.6}$
$y = 23.59"$
$A = 138 + 18.9 + 30.6 = 187.5\ in^2$

SYMONDS
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Project Renton Treatment Plant | Job No. 96005 | Page 2 of
Client Brown and Caldwell | By CJD | Date 7/28/98
Subject Centridry Equipment Study | Checked | Date

Calculate Moment of Inertia of composite section

$I_t = 3100 + 30.6(7.59)^2 + \frac{111}{8}\frac{(8.41)^3}{3}$
$= \underline{7{,}614 \ in^4}$

$I_{gross} = 99{,}941 \ in^3$
$\bar{y} = 9.21''$
$S_b = 4{,}385 \ in^3$

$S_b \ (stl) = \frac{7614}{(32-4 \cdot 8.41)} = 388.66 \ in^3$

$S_t \ (conc) \ \frac{7614}{8.41} = 905.35 \ in^3$

$f_{cr} = 7.5\sqrt{f_c'} = 474 \ psi.$

Moment Capacity $f_c = 1.8 \ ksi$ $F_b = 0.66(36) = 24 \ ksi.$

$M_c = \frac{905.35(1.8)8}{12} = 1086.42^{k'}$

$M_{cr} = \frac{4{,}385(0.474)}{12}$
$M_{cr} = 173^{k'}$

$M_{stl} = \frac{388.66(24)}{12} = 777^{k'}$

$w_L = \frac{(777-406)8}{(37)^2 15} = \underline{0.145} \ ksf$

Calculate loadings on existing beam

beam dead load @ $2.37^{k/'}$
live loading @ floor level to be 100 psf (ACI-350)
Assume weight of steel frame support @ 10 psf
steel grating @ 5 "
15 psf ←

Distribution of equipment weight
$P_1 = 9.93^k$
$P_2 = 11.73^k$

$P_{1D} = 9.93 + 2.03 = 11.96^k$
$P_{1L} = 19.13^k$ (use 50%)
$P_{2D} = 11.73 + 2.03 = 13.76^k$
$P_{2L} = 18.0^k$ (use 50%)

Live load distribution

@ P_1 $\frac{7.5(37)0.10}{2} + 7.5(7)(0.10) = 19.13^k$

@ P_2 $\frac{7.5(37)(0.10)}{2} + 7.5(5.5)(0.10) = 18.0^k$

Dead load distribution @ 15 psf
$15(9)(0.015) = 2.03^k$
Live load from main level
$15.0(0.1) = 1.5^{k/'}$

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Project Renton Treatment Plant Job No. Page of
Client Brown and Caldwell By Date
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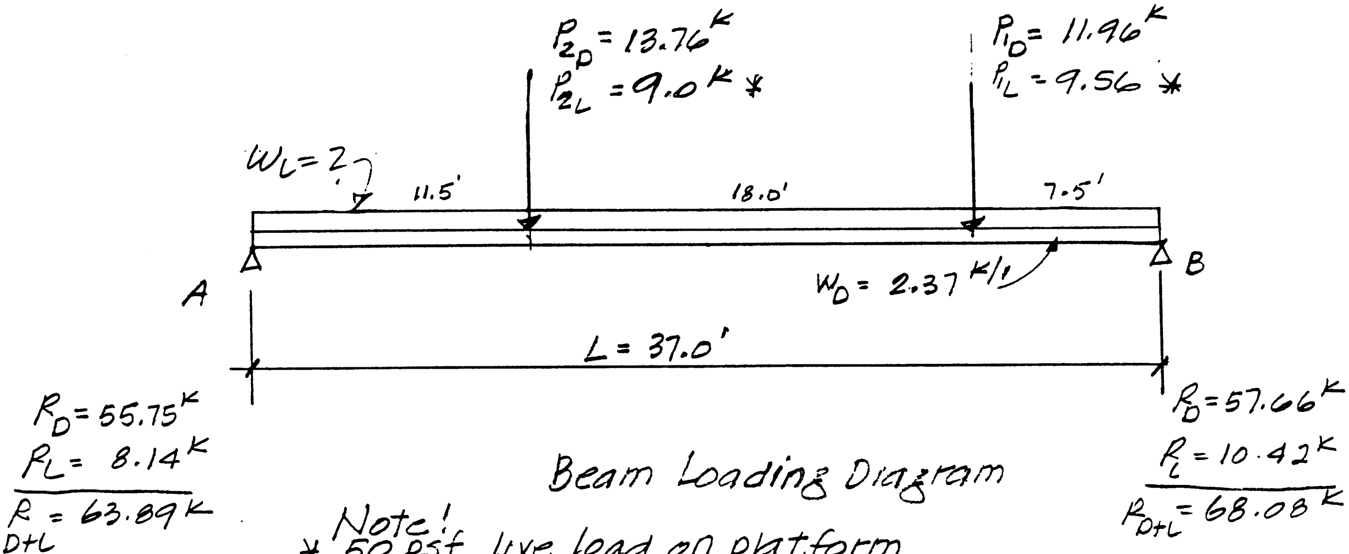

Beam Loading Diagram

Note!
* 50 psf live load on platform
Live load only applied to support platform to determine allowed live load on existing concrete floor system.

Maximum moment

$M_D = 530.2^{k'}$ @ $17.5'$

$M_L = 93.62^{k'}$ @ $11.5'$, 88.46 @ $17.5'$

$M_{D+L} = 618.66^{k'}$ @ $17.5'$

$EI\Delta_{D.L.} = 76885.39$ k-ft^3

with M_{cr} exceeded use
$I_x = 7614$ in^4

$$\Delta_{DL} = \frac{76885.39\,(1728)}{29000\,(7614)} = 0.60 \text{ in} = l/737$$

Live load capacity available on concrete floor

$(777 - 618.66) = 158.34^{k'}$

$$M = \frac{w(37)}{2}(17.5) - \frac{w(17.5)^2}{2} = 158.34$$

$170.63w = 158.34$

$w = 0.928^{k/l}$

$= 62$ psf.

July 28, 1998
1:20 pm

DEAD LOAD

LENGTH = 37

MODULUS OF ELASTICITY = 1

MOMENT OF INERTIA = 1.0000

SUPPORTS:

SUPPORT			FLEXIBILITY COEFFICIENT		FORCED	
Name	Type	Location	Vertical	Rotational	Deflection	Slope
Rs01	Simple	0.0000		ÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄ
Rs02	Simple	37.0000		ÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄ

CONCENTRATED LOADS:

Name	Location	Load
Pt01	11.5000	-13.7600
Pt02	29.5000	-11.9600

UNIFORM LOADS:

Name	Start Location	End Location	Load
Uf01	0.0000	37.0000	-2.3700

REACTIONS:

Name	Location	Vertical	Moment
Rs01	0.0000	55.7526	ÄÄÄÄÄÄÄÄÄÄÄ
Rs02	37.0000	57.6574	ÄÄÄÄÄÄÄÄÄÄÄ

July 28, 1998
1:20 pm

DEAD LOAD (cont)

BEAM VALUES:

Location	Shear	Moment	Slope	Deflection
0.0000	55.7526	0.0000	-6.7E+0003	0.000000
0.5000	54.5676	27.5800	-6.7E+0003	-3.3E+0003
1.0000	53.3826	54.5676	-6.6E+0003	-6.7E+0003
1.5000	52.1976	80.9626	-6.6E+0003	-1.0E+0004
2.0000	51.0126	106.7651	-6.6E+0003	-1.3E+0004
2.5000	49.8276	131.9752	-6.5E+0003	-1.7E+0004
3.0000	48.6426	156.5927	-6.4E+0003	-2.0E+0004
3.5000	47.4576	180.6177	-6.3E+0003	-2.3E+0004
4.0000	46.2726	204.0503	-6.2E+0003	-2.6E+0004
4.5000	45.0876	226.8903	-6.1E+0003	-2.9E+0004
5.0000	43.9026	249.1378	-6.0E+0003	-3.2E+0004
5.5000	42.7176	270.7929	-5.9E+0003	-3.5E+0004
6.0000	41.5326	291.8554	-5.8E+0003	-3.8E+0004
6.5000	40.3476	312.3254	-5.6E+0003	-4.1E+0004
7.0000	39.1626	332.2030	-5.4E+0003	-4.4E+0004
7.5000	37.9776	351.4880	-5.3E+0003	-4.6E+0004
8.0000	36.7926	370.1805	-5.1E+0003	-4.9E+0004
8.5000	35.6076	388.2806	-4.9E+0003	-5.1E+0004
9.0000	34.4226	405.7881	-4.7E+0003	-5.4E+0004
9.5000	33.2376	422.7031	-4.5E+0003	-5.6E+0004
10.0000	32.0526	439.0257	-4.3E+0003	-5.8E+0004
10.5000	30.8676	454.7557	-4.1E+0003	-6.0E+0004
11.0000	29.6826	469.8932	-3.8E+0003	-6.2E+0004
11.5000	14.7376	484.4383	-3.6E+0003	-6.4E+0004
12.0000	13.5526	491.5108	-3.3E+0003	-6.6E+0004
12.5000	12.3676	497.9908	-3.1E+0003	-6.8E+0004
13.0000	11.1826	503.8784	-2.8E+0003	-6.9E+0004
13.5000	9.9976	509.1734	-2.6E+0003	-7.0E+0004
14.0000	8.8126	513.8759	-2.3E+0003	-7.2E+0004
14.5000	7.6276	517.9860	-2.1E+0003	-7.3E+0004
15.0000	6.4426	521.5035	-1.8E+0003	-7.4E+0004
15.5000	5.2576	524.4285	-1.6E+0003	-7.5E+0004
16.0000	4.0726	526.7611	-1.3E+0003	-7.5E+0004
16.5000	2.8876	528.5011	-1.0E+0003	-7.6E+0004
17.0000	1.7026	529.6486	-7.6E+0002	-7.6E+0004
17.5000	0.5176	530.2037	-5.0E+0002	-7.7E+0004
18.0000	-0.6674	530.1662	-2.3E+0002	-7.7E+0004
18.5000	-1.8524	529.5363	34.127027	-7.7E+0004
19.0000	-3.0374	528.3138	298.614223	-7.7E+0004
19.5000	-4.2224	526.4988	562.342061	-7.7E+0004
20.0000	-5.4074	524.0914	825.014291	-7.6E+0004
20.5000	-6.5924	521.0914	1.1E+0003	-7.6E+0004
21.0000	-7.7774	517.4989	1.3E+0003	-7.5E+0004
21.5000	-8.9624	513.3140	1.6E+0003	-7.4E+0004
22.0000	-10.1474	508.5365	1.9E+0003	-7.4E+0004
22.5000	-11.3324	503.1665	2.1E+0003	-7.3E+0004
23.0000	-12.5174	497.2041	2.4E+0003	-7.1E+0004
23.5000	-13.7024	490.6491	2.6E+0003	-7.0E+0004
24.0000	-14.8874	483.5016	2.9E+0003	-6.9E+0004

DEAD LOAD (cont)

BEAM VALUES (Cont):

Location	Shear	Moment	Slope	Deflection
24.5000	-16.0724	475.7617	3.1E+0003	-6.7E+0004
25.0000	-17.2574	467.4292	3.3E+0003	-6.6E+0004
25.5000	-18.4424	458.5042	3.6E+0003	-6.4E+0004
26.0000	-19.6274	448.9868	3.8E+0003	-6.2E+0004
26.5000	-20.8124	438.8768	4.0E+0003	-6.0E+0004
27.0000	-21.9974	428.1743	4.2E+0003	-5.8E+0004
27.5000	-23.1824	416.8794	4.4E+0003	-5.6E+0004
28.0000	-24.3674	404.9919	4.6E+0003	-5.4E+0004
28.5000	-25.5524	392.5119	4.8E+0003	-5.1E+0004
29.0000	-26.7374	379.4395	5.0E+0003	-4.9E+0004
29.5000	-39.8824	365.7745	5.2E+0003	-4.6E+0004
30.0000	-41.0674	345.5370	5.4E+0003	-4.4E+0004
30.5000	-42.2524	324.7071	5.6E+0003	-4.1E+0004
31.0000	-43.4374	303.2846	5.7E+0003	-3.8E+0004
31.5000	-44.6224	281.2696	5.9E+0003	-3.5E+0004
32.0000	-45.8074	258.6622	6.0E+0003	-3.2E+0004
32.5000	-46.9924	235.4622	6.1E+0003	-2.9E+0004
33.0000	-48.1774	211.6697	6.2E+0003	-2.6E+0004
33.5000	-49.3624	187.2848	6.3E+0003	-2.3E+0004
34.0000	-50.5474	162.3073	6.4E+0003	-2.0E+0004
34.5000	-51.7324	136.7373	6.5E+0003	-1.7E+0004
35.0000	-52.9174	110.5749	6.6E+0003	-1.3E+0004
35.5000	-54.1024	83.8199	6.6E+0003	-1.0E+0004
36.0000	-55.2874	56.4724	6.6E+0003	-6.7E+0003
36.5000	-56.4724	28.5325	6.7E+0003	-3.3E+0003
37.0000	-57.6574	0.0000	6.7E+0003	-0.000000

END OF REPORT

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LIVE LOAD

LENGTH = 37

MODULUS OF ELASTICITY = 1

MOMENT OF INERTIA = 1.0000

SUPPORTS:

SUPPORT			FLEXIBILITY COEFFICIENT		FORCED	
Name	Type	Location	Vertical	Rotational	Deflection	Slope
Rs01	Simple	0.0000		ÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄ
Rs02	Simple	37.0000		ÄÄÄÄÄÄÄÄÄÄ		ÄÄÄÄÄÄÄÄÄ

CONCENTRATED LOADS:

Name	Location	Load
Pt01	11.5000	-9.0000
Pt02	29.5000	-9.5600

REACTIONS:

Name	Location	Vertical	Moment
Rs01	0.0000	8.1405	ÄÄÄÄÄÄÄÄÄÄÄ
Rs02	37.0000	10.4195	ÄÄÄÄÄÄÄÄÄÄÄ

LIVE LOAD (cont)

BEAM VALUES:

Location	Shear	Moment	Slope	Deflection
0.0000	8.1405	0.0000	-1.2E+0003	0.000000
0.5000	8.1405	4.0703	-1.2E+0003	-5.8E+0002
1.0000	8.1405	8.1405	-1.2E+0003	-1.2E+0003
1.5000	8.1405	12.2108	-1.2E+0003	-1.7E+0003
2.0000	8.1405	16.2811	-1.2E+0003	-2.3E+0003
2.5000	8.1405	20.3514	-1.1E+0003	-2.9E+0003
3.0000	8.1405	24.4216	-1.1E+0003	-3.5E+0003
3.5000	8.1405	28.4919	-1.1E+0003	-4.0E+0003
4.0000	8.1405	32.5622	-1.1E+0003	-4.6E+0003
4.5000	8.1405	36.6324	-1.1E+0003	-5.1E+0003
5.0000	8.1405	40.7027	-1.1E+0003	-5.7E+0003
5.5000	8.1405	44.7730	-1.0E+0003	-6.2E+0003
6.0000	8.1405	48.8432	-1.0E+0003	-6.7E+0003
6.5000	8.1405	52.9135	-1.0E+0003	-7.2E+0003
7.0000	8.1405	56.9838	-9.7E+0002	-7.7E+0003
7.5000	8.1405	61.0541	-9.4E+0002	-8.2E+0003
8.0000	8.1405	65.1243	-9.1E+0002	-8.6E+0003
8.5000	8.1405	69.1946	-8.7E+0002	-9.1E+0003
9.0000	8.1405	73.2649	-8.4E+0002	-9.5E+0003
9.5000	8.1405	77.3351	-8.0E+0002	-9.9E+0003
10.0000	8.1405	81.4054	-7.6E+0002	-1.0E+0004
10.5000	8.1405	85.4757	-7.2E+0002	-1.1E+0004
11.0000	8.1405	89.5459	-6.7E+0002	-1.1E+0004
11.5000	-0.8595	93.6162	-6.3E+0002	-1.1E+0004
12.0000	-0.8595	93.1865	-5.8E+0002	-1.2E+0004
12.5000	-0.8595	92.7568	-5.4E+0002	-1.2E+0004
13.0000	-0.8595	92.3270	-4.9E+0002	-1.2E+0004
13.5000	-0.8595	91.8973	-4.4E+0002	-1.2E+0004
14.0000	-0.8595	91.4676	-4.0E+0002	-1.3E+0004
14.5000	-0.8595	91.0378	-3.5E+0002	-1.3E+0004
15.0000	-0.8595	90.6081	-3.1E+0002	-1.3E+0004
15.5000	-0.8595	90.1784	-2.6E+0002	-1.3E+0004
16.0000	-0.8595	89.7486	-2.2E+0002	-1.3E+0004
16.5000	-0.8595	89.3189	-1.7E+0002	-1.3E+0004
17.0000	-0.8595	88.8892	-1.3E+0002	-1.3E+0004
17.5000	-0.8595	88.4595	-82.494595	-1.3E+0004
18.0000	-0.8595	88.0297	-38.372297	-1.4E+0004
18.5000	-0.8595	87.6000	5.535135	-1.4E+0004
19.0000	-0.8595	87.1703	49.227703	-1.4E+0004
19.5000	-0.8595	86.7405	92.705405	-1.3E+0004
20.0000	-0.8595	86.3108	135.968243	-1.3E+0004
20.5000	-0.8595	85.8811	179.016216	-1.3E+0004
21.0000	-0.8595	85.4514	221.849324	-1.3E+0004
21.5000	-0.8595	85.0216	264.467568	-1.3E+0004
22.0000	-0.8595	84.5919	306.870946	-1.3E+0004
22.5000	-0.8595	84.1622	349.059459	-1.3E+0004
23.0000	-0.8595	83.7324	391.033108	-1.3E+0004
23.5000	-0.8595	83.3027	432.791892	-1.2E+0004
24.0000	-0.8595	82.8730	474.335811	-1.2E+0004

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LIVE LOAD (cont)

BEAM VALUES (Cont):

Location	Shear	Moment	Slope	Deflection
24.5000	-0.8595	82.4432	515.664865	-1.2E+0004
25.0000	-0.8595	82.0135	556.779054	-1.2E+0004
25.5000	-0.8595	81.5838	597.678378	-1.1E+0004
26.0000	-0.8595	81.1541	638.362838	-1.1E+0004
26.5000	-0.8595	80.7243	678.832432	-1.1E+0004
27.0000	-0.8595	80.2946	719.087162	-1.0E+0004
27.5000	-0.8595	79.8649	759.127027	-1.0E+0004
28.0000	-0.8595	79.4351	798.952027	-9.6E+0003
28.5000	-0.8595	79.0054	838.562162	-9.2E+0003
29.0000	-0.8595	78.5757	877.957432	-8.8E+0003
29.5000	-10.4195	78.1459	917.137838	-8.3E+0003
30.0000	-10.4195	72.9362	954.908378	-7.9E+0003
30.5000	-10.4195	67.7265	990.074054	-7.4E+0003
31.0000	-10.4195	62.5168	1.0E+0003	-6.9E+0003
31.5000	-10.4195	57.3070	1.1E+0003	-6.4E+0003
32.0000	-10.4195	52.0973	1.1E+0003	-5.8E+0003
32.5000	-10.4195	46.8876	1.1E+0003	-5.3E+0003
33.0000	-10.4195	41.6778	1.1E+0003	-4.7E+0003
33.5000	-10.4195	36.4681	1.1E+0003	-4.2E+0003
34.0000	-10.4195	31.2584	1.2E+0003	-3.6E+0003
34.5000	-10.4195	26.0486	1.2E+0003	-3.0E+0003
35.0000	-10.4195	20.8389	1.2E+0003	-2.4E+0003
35.5000	-10.4195	15.6292	1.2E+0003	-1.8E+0003
36.0000	-10.4195	10.4195	1.2E+0003	-1.2E+0003
36.5000	-10.4195	5.2097	1.2E+0003	-6.0E+0002
37.0000	-10.4195	0.0000	1.2E+0003	-0.000000

END OF REPORT

SYMONDS
CONSULTING ENGINEERS
1601 Second Ave. · Suite 1000 · Seattle, WA 98101-1541
P: 206/441-1855 · F: 206/448-7167

Project	Renton Treatment Plant	Job No.		Page	of
Client	Brown and Caldwell	By	CID	Date	
Subject	Centridry Equipment study	Checked		Date	

Determine structure vibration charactoristics –

Deflection from dead load + machine load = 0.6"
near mid span

$$F_N = \frac{213}{\sqrt{D}} = \frac{213}{\sqrt{0.6}} = 275 \text{ cycles/min.}$$

Operating speed 2750 RPM (cycles per min)

Ratio $\frac{275}{2750} = 0.1 < 0.5$ O.K.

CENTRIDRY Equipment Sizing

Dynamic Loads CD 3074 Machine

dynamic loads in N (Newtons), preliminary
Weight to include main drive motor, hydraulic conveyor drive pump unit and lubrication unit - 26630 N
Total operating weight 102,580 + 26630 = 129,210 N (29050 pounds)

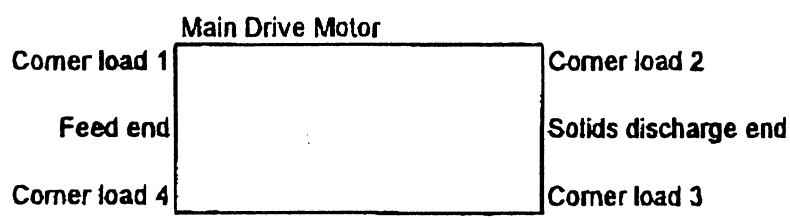
Corner load no.	Static load	Vertical direction Operating speed 2750 RPM	Vertical direction Passing resonance	Horizontal direction Operating speed 2750 RPM	Horizontal direction Passing resonance
1	27890	1395	8367	558	2789
2	23400	1170	7020	468	2340
3	23400	1170	7020	468	2340
4	27890	1395	8367	558	2789

Dynamic Loads CD 3094 Machine

dynamic loads in N (Newtons), preliminary
Weight to include main drive motor, hydraulic conveyor drive pump unit and lubrication unit - 58886 N
Total operating weight 248,300 + 58,886 = 307,200 N (69,000 pounds)

Corner load no.	Static load	Vertical direction Operating speed 2400 RPM	Vertical direction Passing resonance	Horizontal direction Operating speed 2400 RPM	Horizontal direction Passing resonance
1	54100	5920	19750	1980	4550
2	70050	7720	25750	2570	5150
3	70050	7720	25750	2570	5150
4	54100	5920	19750	1980	4550

Corner Identification



...ed, special precautions should ... to avoid this problem. A number of techniques have been used including shear transfer with dowels and steel waterstops, relocation of the waterstop, and redesign to avoid the necessity of shear transfer.

2.9—Impact, vibration, torque, and seismic loads

To maintain the watertightness of a structure, it is essential that cracking and crack widths be kept to a minimum. Accordingly, special care is needed in designing for impact and vibration, both of which can initiate or propagate cracks. In particular, the effect of vibration is cumulative, and cracks will continue to develop and grow with time. It is, therefore, important that corrective action to reduce the vibration be taken as early as possible in structures where vibrations have caused cracking.

2.9.1 *Impact* — Impact loads are seldom encountered in sanitary engineering structures. When they are present, a conservative design approach is recommended to keep cracking to a minimum. Design for impact should be as thorough as possible. However, where a complete shock analysis is not practical, standard impact factors should be used and design should be based on the stresses recommended in Section 2.6. An appropriate impact allowance, frequently in the range of 25 percent of the weight, is used for heavy machines.

2.9.2 *Vibration* — Most of the mechanical equipment associated with sanitary engineering structures, such as scrapers, clarifiers, certain types of flocculators, and rotating vacuum screens, is basically slow moving and will not cause structural vibrations. For such equipment, a separate design for dynamic loading is unnecessary. Other commonly used machines, such as centrifugal pumps, fans, centrifuges, and compressors, have much higher rotational speeds and require special considerations in the design of their support structures and foundations. Usually, the value of such machines is so much more than the cost of the foundation that it is imprudent to economize on foundation costs and run the risk of shortened machine life, increased maintenance costs, and breakdowns.

In sanitary engineering structures, the machines which most often cause vibration problems are forced draft fans and centrifuges used for dewatering clarifier sludge or digester sludge. These are very sensitive machines and need carefully designed foundations with no critical resonant vibration. Chemical mixers may also serve as the source of significant dynamic loads. The supports of such mixers are particularly prone to vibration.

The key to successful dynamic design is to insure that the natural frequency of the machinery support structure is significantly different from the frequency of the disturbing force. If the two frequencies approach each other, resonant vibrations will be set up in the support structure. To minimize resonant vibrations, the ratio of the natural frequency of the structure to the frequency of the disturbing force should be kept out of the range from 0.5 to 1.5. As discussed later in this section, it is preferable to maintain a frequency ratio above 1.5.

For spread foundations, the safe-bearing load is frequently assumed as one-half of the permissible safe load for statically loaded foundations at the same location and on the same soil or rock.[10,11] Some equipment manufacturers recommend minimum foundation/equipment mass ratios, generally in the range of four to six. Adherence to this rule has not always proved satisfactory,[12] and to insure that the equipment will not be in resonance with the foundation, it is recommended that the natural frequency of the foundation system be calculated. For natural frequency calculations, follow the method recommended in Reference 10. For piled foundations, follow the recommendations found in References 13, 14, and 15. Often the machine foundation is insulated or entirely separated from the floors and other parts of the structure, minimizing transmission of vibration to other areas of the building. More detailed information on the dynamic design of foundations can be found in Reference 16.

If the machine is not directly supported on a solid foundations but on columns and beams, it is the natural frequency of the support members that is of primary importance. Needless to say, the strength of these members must also be within acceptable limits.

The natural frequency of a structure should be calculated for the vertical direction and for the two principal horizontal directions. To combine the effect of several masses, such as those due to the machine and the structure, the natural frequency can be calculated using the following formula

$$F_N = \frac{1}{\sqrt{\frac{1}{F_1^2} + \frac{1}{F_2^2} + \frac{1}{F_3^2} + \frac{1}{F_4^2} \cdots}}$$

where

F_N = combined natural frequency
F_1 = natural frequency due to Mass 1
F_2 = natural frequency due to Mass 2
F_3 = natural frequency due to Mass 3
F_4 = natural frequency due to Mass 4

The individual frequencies, in cycles per minute, can be calculated using the expressions given in Table 2.9.2a, in which D is the immediate deflection due to the mass being considered. Gravity should be assumed to act in the direction of vibration, and in lieu of a comprehensive analysis, D can be calculated using the method outlined in Section 9.5.2.3 of ACI 318.

The preceeding equations provide a simple method of computing the natural frequency of a structure from its static deflection. For the case of a concentrated load only, Table 2.9.2b relates the static deflection of a structure supporting an item of equipment to the natural frequency of that structure as calculated using the equations. A similar table can be developed for struc-

Table 2.9.2a — Natural frequencies of beams

End condition		Load	Position of deflection D	Natural frequency, cycles per minute: Where D is deflection in in.	Natural frequency, cycles per minute: Where D is deflection in mm
End 1	End 2				
Fixed	Free	Uniform	End 2	$\frac{233}{\sqrt{D}}$	$\frac{1174}{\sqrt{D}}$
Pin or Fixed	Pin or Fixed	Uniform	Midspan	$\frac{213}{\sqrt{D}}$	$\frac{1073}{\sqrt{D}}$
Fixed or Fixed or Pin	Fixed or Free or Pin	Concentrated (any position)	Under load	$\frac{188}{\sqrt{D}}$	$\frac{947}{\sqrt{D}}$

Table 2.9.2b — Recommended maximum structural deflection for given equipment operating speeds

Operating speed of machinery, cycles per min	Recommended minimum natural frequency of structure, cycles per min (from formula)	Maximum static deflection of structure due to dead load and machinery load, in.
400 6.67 Hz	600 10.0 Hz	0.10 (2.54 mm)
600 10.0 Hz	900 15.0 Hz	0.044 (1.12 mm)
800 13.3 Hz	1200 20.0 Hz	0.025 (0.635 mm)
1000 16.7 Hz	1500 25.0 Hz	0.016 (0.406 mm)
1200 20.0 Hz	1800 30.0 Hz	0.011 (0.279 mm)
2000 33.3 Hz	3000 50.0 Hz	0.0040 (0.102 mm)
2400 40.0 Hz	3600 60.0 Hz	0.0027 (0.069 mm)

tures in which the uniform loads or other loads are significant. As stated, the ratio of natural frequency of the structure to frequency of the machinery or other disturbing force should be either less than 0.5 or greater than 1.5, preferably the latter. Table 2.9.2b shows recommended maximum structural deflections for given equipment operating speeds.

Theoretically, the natural frequency of the structure could also be lower than the operating rotation of the machine and thus avoid resonant vibration. In this case, the natural frequency of the support should be at least 50 percent below the operating frequency of the machinery. A disadvantage of this is that the machine would pass through the critical cycle at startup and shutdown. It is not likely that the short coincidence of time would cause damage to the machine, but generally it is preferable to keep the deflection low and the natural frequency of the structure well above operating speed. It is also possible that the machine will be operated at a lower speed for some time, and this lower speed could coincide with, or be close to, the critical frequency of resonant vibration.

If the machinery is installed on an upper floor, the use of vibration isolators is recommended, but this should not be considered a substitute for dynamic structural design, since all isolators transmit some vibration.

A more complete discussion of dynamic analysis methods is given in References 17, 18, 19, and 20.

2.9.3 *Torque* — In some cases, it may be necessary to consider torque in the design of the structure. Large circular clarifiers frequently fall into this category.

Most clarifiers support the entire mechanism on a center column. The diameters of clarifiers are steadily increasing and there are now clarifiers of 500 ft (152 m) diameter in operation. These clarifiers have cantilever scrapers close to 250 ft (76 m) in length. Stalling torques of up to 5,000,000 lb-ft (6,780,000 N-m) are specified, and the foundation must be able to resist this load. There have been cases where the center column has sheared off from the foundation. Often a limit switch is included in the mechanism to prevent overload of the structure.

In a few types of clarifiers, the radial scrapers are supported on a center column but driven by a carriage that rides on the periphery of the clarifier. With this type, horizontal reactions occur both at the center column and at the periphery, and there is no torque.

The sludge accumulation, which produces the specified stalling torque, is assumed to be a triangular horizontal load on the cantilever arms, the maximum being at the center and tapering off to zero at the circumference. This corresponds with the probable pattern of the sludge accumulation.

From the viewpoint of the foundation, the load distribution on the steel structure is immaterial. However, the magnitude of the stalling torque is important, and the foundation and the center column usually are designed to resist a torque of 50 percent in excess of the stalling torque. The resisting earth friction and passive earth pressure have small lever arms about the center of the torque, and it is possible, if the foundation is small, or in loose fills or slippery silts, for the clarifier drive mechanism to start turning the center column foundation.

The torque resistance of the foundation can be increased by the use of batter piles at the periphery of the foundation. Increasing the friction by increasing the foundation weight and/or increasing the area of the foundation to give a bigger lever arm will also provide greater torque resistance.

2.9.4 *Design of tanks to resist seismic loads* — In design of tanks to resist seismic loads, the hydrodynamic mass of the contained fluid should be considered in the seismic load determination. This applies to both open and enclosed tanks, and to all sizes and shapes, e.g., square, rectangular, and circular.

Hydrodynamic pressures should include both impulsive and convective components. Impulsive pressures are developed by accelerations of the tank walls acting against the mass of the contained liquid. Convective pressures are those produced by oscillations (sloshing) of the liquid within the tanks.

In addition to the preceeding, the tanks should also be designed to include seismic effects of external earth pressures and dead loads of the structure.

Methodology for developing hydrodynamic pressures has been developed by G. W. Housner and is contained in Reference 8. Additional information on seismic induced loadings of sanitary facilities is contained in Reference 25.

Seismic action can induce large horizontal and overturning forces on sanitary structures. Because of this, special provisions may be required when joints at the

TAB

H

APPENDIX H

CAPITAL COST EVALUATION: ALTERNATIVES 0, 1, 2, AND 3

ALTERNATIVE 0

REPLACE EXIST. 8 BFP'S WITH 3 LARGE CENTRIFUGES

REVISED

Prepared By Brown and Caldwell, February 12, 2002

Preliminary Cost Estimate

Demolition of Existing Belt Filter Presses

WORK TO FOLLOW COMMISSIONING OF TWO CENTRIFUGES

				Material Cost		Labor				Equipment		
Item	Description	Quantity	Unit	Unit Cost	Amount	Labor Hr.	Total Hr.	Rate	Amount	Unit Cost	Amount	Total
1	Remove Roof Hatch	6	EA	$250.00	$1,500	16	96	$48	$4,608	$300.00	$1,800	$7,908
2	**Remove Portion of FA System**	1	LS	$0.00	$0	0	0	$48	$0	$0.00	$0	$0
2a	Remove Hood and Cables	8	EA	$0.00	$0	8	64	$48	$3,072	$50.00	$400	$3,472
2b	Remove 54-Inch FA Pipe	50	LF	$0.00	$0	1	50	$48	$2,400	$0.00	$0	$2,400
2c	Remove 20-Inch FA Pipe	20	LF	$0.00	$0	0.3	6	$48	$288	$0.00	$0	$288
2d	Remove 30-Inch FA Pipe	36	LF	$0.00	$0	0.5	18	$48	$864	$0.00	$0	$864
2e	Remove 24-Inch FA Pipe	24	LF	$0.00	$0	0.35	8.4	$48	$403	$0.00	$0	$403
2f	R3move 24-Inch Elbows	8	EA	$0.00	$0	1	8	$48	$384	$0.00	$0	$384
3	**Remove Belt Filter Presses**	8	EA	$500.00	$4,000	100	800	$48	$38,400	$2,000.00	$16,000	$58,400
3a	Cut Bolts and Patch Surface	192	EA	$3.00	$576	0.35	67.2	$35	$2,352	$0.00	$0	$2,928
3b	Remove Piping Connections	8	EA	$50.00	$400	16	128	$48	$6,144	$75.00	$600	$7,144
3c	Remove Structural Support System	8	EA	$0.00	$0	32	256	$35	$8,960	$250.00	$2,000	$10,960
3d	Remove Bridge Section	4	EA	$0.00	$0	12	48	$35	$1,680	$75.00	$300	$1,980
3e	Remove BS Piping to Floor	350	LF	$0.00	$0	0.16	56	$48	$2,688	$0.25	$88	$2,776
3f	Salvage Flow Elements	8	EA	$25.00	$200	2	16	$48	$768	$0.00	$0	$968
4	**Remove Feed Pump**	8	EA	$50.00	$400	16	128	$48	$6,144	$150.00	$1,200	$7,744
4a	Break Out Concrete Base	8	EA	$0.00	$0	16	128	$35	$4,480	$150.00	$1,200	$5,680
4b	Cut Bolts/Rebar	128	EA	$0.00	$0	0.25	32	$35	$1,120	$0.00	$0	$1,120
4c	Isolate Seal Water Piping	8	EA	$25.00	$200	1	8	$48	$384	$0.00	$0	$584
4d	**Remove Exist. Polymer Pump**	8	EA	$50.00	$400	6	48	$48	$2,304	$75.00	$600	$3,304
5	**Remove Washwater Pump**	8	EA	$50.00	$400	12	96	$48	$4,608	$100.00	$800	$5,808
5a	Break Out Concrete Base	8	EA	$0.00	$0	16	128	$35	$4,480	$150.00	$1,200	$5,680
5b	Remove Piping	8	EA	$0.00	$0	16	128	$48	$6,144	$100.00	$800	$6,944
5c	Isolate Seal Water Piping	8	EA	$25.00	$200	1	8	$48	$384	$0.00	$0	$584
6	Demo Piping	1	LS	$0.00	$0	0	0	$35	$0	$0.00	$0	$0
6a	Cap 4-Inch POL Piping	8	EA	$4.00	$32	0.5	4	$48	$192	$0.00	$0	$224
6b	Remove 6-Inch Filtrate Piping	500	LF	$0.00	$0	0.16	80	$35	$2,800	$0.00	$0	$2,800
6c	Cap Unused Pipe Penetrations	13	EA	$50.00	$650	1	13	$48	$624	$0.50	$7	$1,281
6d	Remove 6-Inch BS Piping	450	LF	$0.00	$0	0.16	72	$35	$2,520	$0.50	$225	$2,745
6e	Remove Portion of 10-Inch BS	64	LF	$0.00	$0	0.16	10.24	$35	$358	$0.50	$32	$390
6f	Remove Drain Piping	8	EA	$0.00	$0	4	32	$35	$1,120	$0.00	$0	$1,120
7	**Remove MCC CB's**	16	EA	$0.00	$0	8	128	$48	$6,144	$0.00	$0	$6,144
7a	Remove Conductors	8	EA	$0.00	$0	40	320	$48	$15,360	$75.00	$600	$15,960
7b	Remove BFP Control Panel	8	EA	$200.00	$1,600	40	320	$48	$15,360	$150.00	$1,200	$18,160
8	**Remove Conveyors**	168	LF	$0.00	$0	0.5	84	$35	$2,940	$1.50	$252	$3,192
8a	Cut Anchor Bolts	85	EA	$0.00	$0	0.05	4.25	$35	$149	$0.00	$0	$149
8b	Epoxy Patch Anchor Bolts	85	EA	$0.50	$43	0.05	4.25	$35	$149	$0.00	$0	$191
9	**Break Out Conc. Filtrate Contain.**	43	CY	$0.00	$0	6	258	$35	$9,030	$25.00	$1,075	$10,105
9a	Sandblast Conc. Surface	2,300	SF	$0.21	$483	0.022	50.6	$35	$1,771	$0.05	$115	$2,369
9b	Restore Floor Surface	2,300	SF	$3.00	$6,900	0	0	$35	$0	$0.00	$0	$6,900
9c	Remove Conc. Curbs	12	CY	$0.00	$0	4	48	$35	$1,680	$25.00	$300	$1,980
9d	Cut Rebar @ Floor	624	EA	$0.00	$0	0.05	31.2	$35	$1,092	$0.00	$0	$1,092
9e	Patch Rebar @ Floor	624	EA	$0.50	$312	0.05	31.2	$35	$1,092	$0.00	$0	$1,404

9f	Sandblast Conc. Surface	312	SF	$0.21	$66	0.022	6.864	$35	$240	$0.05	$16	$321	
9g	Restore Floor Surface	312	SF	$3.00	$936	0	0	$35	$0	$0.00	$0	$936	
10	**Remove Grinders**	2	EA	$0.00	$0	16	32	$35	$1,120	$100.00	$200	$1,320	
10a	Remove Control Panels	2	EA	$0.00	$0	16	32	$45	$1,440	$50.00	$100	$1,540	
11	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
12	Replace/Seal Roof Hatches	6	EA	$1,500.00	$9,000	16	96	$35	$3,360	$300.00	$1,800	$14,160	
Subtotal Initial Demolition					$28,297		3983.204		$171,600		$32,909	$232,806	$232,806

Extend Existing Dewatering Building South and East to Facilitate Centrifuge Units And Truck Scale

1	Asphalt Removal	370	SY	$0.00	$0	0	0	$35	$0	$2.90	$1,073	$1,073
1a	Saw Cut Asphalt	190	LF	$0.00	$0	0	0	$35	$0	$0.95	$181	$181
1b	Site Excavation	675	CY	$0.00	$0	0	0	$35	$0	$3.50	$2,363	$2,363
1c	Material Disposal (on site)	675	CY	$0.00	$0	0	0	$35	$0	$8.00	$5,400	$5,400
1d	Structural Fill (1.5')	200	CY	$12.00	$2,400	0.16	32	$35	$1,120	$1.50	$300	$3,820
1e	Base Rock	67	CY	$15.00	$1,005	0.16	10.72	$35	$375	$1.50	$101	$1,481
1f	Vapor Barrier	325	SY	$1.50	$488	0	0	$35	$0	$0.00	$0	$488
2	**Extend Truck Bay to Line 0, Elev 111**	1	LS	$0.00	$0	0	0	$35	$0	$0.00	$0	$0
2a	Slab On Grade	40	CY	$350.00	$14,000	0	0	$35	$0	$20.00	$800	$14,800
2b	Extend Center wall section	18	CY	$400.00	$7,200	0	0	$35	$0	$20.00	$360	$7,560
2c	Extend side wall sections	24	CY	$400.00	$9,600	0	0	$35	$0	$20.00	$480	$10,080
2d	Extend Cant. One side only	16	CY	$400.00	$6,400	0	0	$35	$0	$20.00	$320	$6,720
2e	Extend Slab North of Truck Bays	20	CY	$350.00	$7,000	0	0	$35	$0	$20.00	$400	$7,400
2f	Extend Slab South of Truck Bays 20'	27	CY	$350.00	$9,450	0	0	$35	$0	$20.00	$540	$9,990
2g	Drill Holes Existing Slab	170	EA	$2.00	$340	0.25	42.5	$35	$1,488	$0.00	$0	$1,828
2h	Set Dowel Bars Existing Slab	170	EA	$1.50	$255	0.1	17	$35	$595	$0.00	$0	$850
2i	East End Wall	49	CY	$350.00	$17,150	0	0	$35	$0	$20.00	$980	$18,130
3	**Extend Build Slab South, Elev 111**	120	CY	$350.00	$42,000	0	0	$35	$0	$20.00	$2,400	$44,400
3a	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0
4	**Ground Floor Concrete Walls**	61	CY	$400.00	$24,400	0	0	$35	$0	$20.00	$1,220	$25,620
4a	Ground Floor H Columns (10 ea)	123	LF	$44.00	$5,412	0.054	6.642	$40	$266	$1.25	$154	$5,831
4b	H Column Encasement	11	CY	$475.00	$5,225	0	0	$35	$0	$20.00	$220	$5,445
4c	Perimeter Steel Beams W24X55 @ El 126	222	LF	$37.00	$8,214	0.072	15.984	$40	$639	$1.36	$302	$9,155
4d	Perimeter Steel Beams W10 X33 @ El 126	160	LF	$22.00	$3,520	0.102	16.32	$40	$653	$2.58	$413	$4,586
4e	Beam to Column Attachment	30	EA	$150.00	$4,500	2	60	$40	$2,400	$10.00	$300	$7,200
4f	Perimeter Beam Encasement	53	CY	$475.00	$25,175	0	0	$35	$0	$20.00	$1,060	$26,235
4g	Chip Out Existing Columns	3	EA	$1,500.00	$4,500	0	0	$35	$0	$0.00	$0	$4,500
4h	Steel Column Attachment	3	EA	$750.00	$2,250	0	0	$35	$0	$0.00	$0	$2,250
4i	Precast Curb Wall @ Perimeter	9	CY	$400.00	$3,600	0	0	$35	$0	$20.00	$180	$3,780
5	**Second Floor Slab @ El 126**	99	CY	$450.00	$44,550	0	0	$35	$0	$20.00	$1,980	$46,530
5a	Second Floor H Columns (10 ea)	220	LF	$44.00	$9,680	0.054	11.88	$40	$475	$1.25	$275	$10,430
5b	H Column Encasement	18	CY	$475.00	$8,550	0	0	$35	$0	$20.00	$360	$8,910
5c	Perimeter Steel Beams W24X55 @ El 126	222	LF	$37.00	$8,214	0.072	15.984	$40	$639	$1.36	$302	$9,155
5d	Perimeter Steel Beams W10 X33 @ El 126	160	LF	$22.00	$3,520	0.102	16.32	$40	$653	$2.58	$413	$4,586
5e	Perimeter Beam Encasement @ El 150	48	CY	$475.00	$22,800	0	0	$35	$0	$20.00	$960	$23,760
5f	Beam to Column Attachment	30	EA	$150.00	$4,500	2	60	$40	$2,400	$10.00	$300	$7,200
6	**Roof Slab @ El 150**	66	CY	$450.00	$29,700	0	0	$35	$0	$20.00	$1,320	$31,020
6a	Cants	316	LF	$2.03	$641	0.025	7.9	$35	$277	$0.00	$0	$918
6b	3-Inch Roof Insulation	2,670	SF	$3.12	$8,330	0.011	29.37	$35	$1,028	$0.00	$0	$9,358
6c	4-Ply Built Up Roofing	2,670	SF	$0.64	$1,709	0.028	74.76	$35	$2,617	$0.16	$427	$4,753
6d	Gravel Cover	2,670	SF	$0.38	$1,015	0.002	5.34	$35	$187	$0.14	$374	$1,575
6e	Roof Drains	4	EA	$100.00	$400	1	4	$40	$160	$0.00	$0	$560
6f	Scuppers	4	EA	$50.00	$200	1	4	$35	$140	$0.00	$0	$340
6g	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0
7	**Precast Wall Panels**	4,900	SF	$11.50	$56,350	0.04	196	$35	$6,860	$1.00	$4,900	$68,110
8	Panel Seimic Work	1	LS	$25,000.00	$25,000	0	0	$35	$0	$0.00	$0	$25,000

9	New Replacement Truck Bay Doors	4	EA	$15,800.00	$63,200	48	192	$35	$6,720	$1,200.00	$4,800	$74,720	
10	Double Man Door	2	EA	$1,500.00	$3,000	14	28	$35	$980	$0.00	$0	$3,980	
11	Remove Panel At Truck Bay	1	EA	$0.00	$0	32	32	$35	$1,120	$500.00	$500	$1,620	
12	Modify Panels for two Doors	2	EA	$750.00	$1,500	16	32	$35	$1,120	$150.00	$300	$2,920	
12a	Man Doors	1	EA	$1,000.00	$1,000	8	8	$35	$280	$0.00	$0	$1,280	
13	Floor Coating	5,340	SF	$3.50	$18,690	0	0	$35	$0	$0.00	$0	$18,690	
14	Coat Interior Concrete Walls/Ceiling	5,220	SF	$0.20	$1,044	0.015	78.3	$35	$2,741	$0.10	$522	$4,307	
15	Expansion Joint Material 1" X 24"	828	SF	$1.40	$1,159	0.054	44.712	$35	$1,565	$0.00	$0	$2,724	
15a	Joint Sealant 1" X 1"	414	LF	$2.30	$952	0.124	51.336	$35	$1,797	$0.00	$0	$2,749	
15b	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
16	**Construct Concrete Pedistals**	3	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
16a	Drill Holes for Concrete Piers	120	EA	$2.50	$300	0.25	30	$35	$1,050	$0.00	$0	$1,350	
16b	Epoxy Dowel Bars	120	EA	$2.00	$240	0.083	9.96	$35	$349	$0.00	$0	$589	
16c	Concrete Piers	15	CY	$450.00	$6,750	0	0	$35	$0	$20.00	$300	$7,050	
16d	Drill Holes for Walkway Support	250	EA	$2.50	$625	0.25	62.5	$35	$2,188	$0.00	$0	$2,813	
16e	S.S. Anchor Bolts	250	EA	$10.00	$2,500	0.083	20.75	$35	$726	$0.00	$0	$3,226	
16f	Steel Columns	420	LF	$11.20	$4,704	0.0805	33.81	$48	$1,623	$1.45	$609	$6,936	
16g	Weld Beam Connections	300	LF	$0.41	$123	0.1	30	$48	$1,440	$1.03	$309	$1,872	
16h	Horizontal Steel Beams	520	LF	$18.33	$9,532	0.09	46.8	$48	$2,246	$1.56	$811	$12,589	
16i	Post tops 4" X 4" X 1/4"	100	LBS	$1.00	$100	0.3	30	$48	$1,440	$0.00	$0	$1,540	
16j	Weld Cap to Post Top	80	LF	$0.41	$33	0.1	8	$48	$384	$1.03	$82	$499	
16k	Flat Bar X 1/4-Inch	435	LBS	$0.50	$218	0.3	130.5	$48	$6,264	$0.00	$0	$6,482	
16l	Weld Flat Bar to Beams	250	LF	$0.41	$103	0.1	25	$48	$1,200	$1.03	$258	$1,560	
16m	Fiberglass Grating	2,650	SF	$16.60	$43,990	0.04	106	$35	$3,710	$0.00	$0	$47,700	
16n	Hand Rail	450	LF	$26.00	$11,700	0.234	105.3	$35	$3,686	$0.00	$0	$15,386	
16o	Hand Rail Base Plate	50	EA	$15.00	$750	1	50	$35	$1,750	$0.00	$0	$2,500	
16p	Steel Stairs	4	EA	$4,500.00	$18,000	40	160	$35	$5,600	$0.00	$0	$23,600	
16q	Containment Curbs	10	CY	$450.00	$4,500	0	0	$35	$0	$20.00	$200	$4,700	
16r	Splash Slab	32	CY	$300.00	$9,600	0	0	$35	$0	$20.00	$640	$10,240	
16s	Coating	2,000	SF	$3.50	$7,000	0	0	$35	$0	$0.00	$0	$7,000	
16t	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
17	**Remove Precast Pnl @ Elev 126**	2,052	SF	$0.00	$0	0.25	513	$35	$17,955	$2.36	$4,843	$22,798	
17a	Saw Cut Curb Wall	76	LF	$3.22	$245	0.805	61.18	$48	$2,937	$24.75	$1,881	$5,062	
17b	Demo Curb Wall	1	CY	$0.00	$0	27	27	$35	$945	$95.00	$95	$1,040	
17c	Bush Surface	76	SF	$0.03	$2	0.074	5.624	$35	$197	$0.27	$21	$220	
17d	Patch Floor Surface @ Old Curb Line	76	SF	$4.00	$304	0	0	$35	$0	$0.00	$0	$304	
17e	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
18	**Acoustical Wall Treatment @ Elev 126**	4,300	SF	$6.00	$25,800	0.052	223.6	$35	$7,826	$0.10	$430	$34,056	
19	**Line Exist Filtrate Sump**	900	SF	$20.00	$18,000	0	0	$35	$0	$0.00	$0	$18,000	
19a	By Pass Pump & Storage Allowance	1	LS	$0.00	$0	0	0	$35	$0	$15,000.00	$15,000	$15,000	
20	Repair Basement Floor Surfaces	240	SF	$3.50	$840	0.15	36	$35	$1,260	$0.00	$0	$2,100	
21	Equipment and Pipe Painting Allowance	1	LS	$35,000.00	$35,000	0	0	$35	$0	$0.00	$0	$35,000	
22	Scrubber Wall Penetration	2	EA	$500.00	$1,000	16	32	$45	$1,440	$150.00	$300	$2,740	
Subtotal Building Extention					**$721,746**		**2840.092**		**$105,508**		**$63,056**	**$890,309**	**$890,309**

Install Three Centrifuges

1	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
2	**Install Centrifuge**	3	EA	$700,000.00	$2,100,000	400	1200	$48	$57,600	$1,200.00	$3,600	$2,161,200	Note 4
2a	**Centrifuge Screw Conveyor**	3	EA	$6,000.00	$18,000	32	96	$48	$4,608	$5.00	$15	$22,623	
2b	**No./So. Screw Conveyor (2 EA)**	390	LF	$1,000.00	$390,000	1	390	$48	$18,720	$5.00	$1,950	$410,670	
2c	**Truck Load Conveyor (2EA)**	192	LF	$1,000.00	$192,000	1	192	$48	$9,216	$5.00	$960	$202,176	
2d	Modify Drop Chutes	4	EA	$1,000.00	$4,000	8	32	$48	$1,536	$0.00	$0	$5,536	
2e	New Drop Chutes	4	EA	$7,500.00	$30,000	60	240	$48	$11,520	$100.00	$400	$41,920	
3	**Install Sludge Feed Pump**	3	EA	$42,000.00	$126,000	60	180	$48	$8,640	$100.00	$300	$134,940	

3a	Drill Holes for Dowels	72	EA	$2.50	$180	0.25	18	$35	$630	$0.00	$0	$810	
3b	Install Dowels	72	EA	$2.50	$180	0.083	5.976	$35	$209	$0.00	$0	$389	
3ba	Equip. Bases	4	EA	$500.00	$2,000	0	0	$35	$0	$0.00	$0	$2,000	
3c	**Provide VFD**	3	EA	$15,000.00	$45,000	40	120	$48	$5,760	$100.00	$300	$51,060	
3d	10-Inch Suction Header	70	LF	$37.50	$2,625	0.774	54.18	$48	$2,601	$0.00	$0	$5,226	
3e	**New Grinder**	3	EA	$25,000.00	$75,000	40	120	$48	$5,760	$50.00	$150	$80,910	
3f	10-Inch X 8-Inch Reducers	6	EA	$201.00	$1,206	1.2	7.2	$48	$346	$0.00	$0	$1,552	
3g	8-Inch Piping	60	LF	$25.00	$1,500	0.649	38.94	$48	$1,869	$0.00	$0	$3,369	
3h	8-Inch Elbows	10	EA	$157.00	$1,570	1.143	11.43	$48	$549	$0.00	$0	$2,119	
3i	8-Inch Tees	9	EA	$268.00	$2,412	1.714	15.426	$48	$740	$0.00	$0	$3,152	
3j	8-Inch Plug Valves	12	EA	$1,175.00	$14,100	9.6	115.2	$48	$5,530	$0.00	$0	$19,630	
3k	8-Inch flex Coupling	6	EA	$299.00	$1,794	2.963	17.778	$48	$853	$0.00	$0	$2,647	
3l	8-Inch flanges	28	EA	$117.00	$3,276	1.412	39.536	$48	$1,898	$0.00	$0	$5,174	
3m	8-Inch Bolt and Gasket Sets	28	EA	$16.25	$455	0	0	$48	$0	$0.00	$0	$455	
3n	10-Inch Tees	3	EA	$555.00	$1,665	2	6	$48	$288	$0.00	$0	$1,953	
3o	10-Inch Elbows	2	EA	$286.00	$572	1.333	2.666	$48	$128	$0.00	$0	$700	
3oa	Drill Holes for Dowels	54	EA	$2.50	$135	0.25	13.5	$35	$473	$0.00	$0	$608	
3ob	Install Dowels	54	EA	$2.50	$135	0.083	4.482	$35	$157	$0.00	$0	$292	
3oc	Equip. Bases	3	EA	$500.00	$1,500	0	0	$35	$0	$0.00	$0	$1,500	
3p	**10-Inch Suction Piping**	30	LF	$37.50	$1,125	0.774	23.22	$48	$1,115	$0.00	$0	$2,240	
3q	10-Inch Elbows	3	EA	$286.00	$858	1.333	3.999	$48	$192	$0.00	$0	$1,050	
3r	10-Inch Flex Couplings	3	EA	$400.00	$1,200	3.2	9.6	$48	$461	$0.00	$0	$1,661	
3s	1-Inch Weld-O-Let	3	EA	$8.00	$24	0.8	2.4	$48	$115	$2.50	$8	$147	
3t	1-Inch Nipple	3	EA	$1.00	$3	0.48	1.44	$48	$69	$0.00	$0	$72	
3u	Quick coupling	3	EA	$35.00	$105	0.48	1.44	$48	$69	$0.00	$0	$174	
3v	1-Inch Plug Valve	3	EA	$79.00	$237	0.571	1.713	$48	$82	$0.00	$0	$319	
3w	10-Inch Plug Valves	3	EA	$1,725.00	$5,175	10.909	32.727	$48	$1,571	$0.00	$0	$6,746	
3x	10-Inch Flanges	9	EA	$185.00	$1,665	1.714	15.426	$48	$740	$0.00	$0	$2,405	
3y	10-Inch Bolt and Gasket	9	EA	$33.50	$302	0	0	$48	$0	$0.00	$0	$302	
3z	Install Control Panels	3	EA	$0.00	$0	24	72	$48	$3,456	$100.00	$300	$3,756	
4	**8-Inch Discharge Piping**	250	LF	$35.00	$8,750	0.649	162.25	$48	$7,788	$0.00	$0	$16,538	
4a	8-Inch Tee	12	EA	$318.00	$3,816	1.714	20.568	$48	$987	$0.00	$0	$4,803	
4b	8-Inch Elbows	20	EA	$207.00	$4,140	1.143	22.86	$48	$1,097	$0.00	$0	$5,237	
4c	8-Inch X 6-Inch Reducers	6	EA	$110.00	$660	1.043	6.258	$48	$300	$0.00	$0	$960	
4c	8-Inch Plug Valves	11	EA	$1,175.00	$12,925	9.6	105.6	$48	$5,069	$0.00	$0	$17,994	
4d	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
4e	8-Inch Flow Meter	3	EA	$7,500.00	$22,500	16	48	$48	$2,304	$0.00	$0	$24,804	
4f	8-Inch Flex Couplings	3	EA	$299.00	$897	2.963	8.889	$48	$427	$0.00	$0	$1,324	
4g	1-Inch Weld-O-Let	3	EA	$8.00	$24	0.8	2.4	$48	$115	$2.50	$8	$147	
4h	1-Inch Nipple	3	EA	$1.00	$3	0.48	1.44	$48	$69	$0.00	$0	$72	
4i	1-Inch Plug Valve	3	EA	$79.00	$237	0.571	1.713	$48	$82	$0.00	$0	$319	
4j	1-Inch Quick Coupling	3	EA	$35.00	$105	0.48	1.44	$48	$69	$0.00	$0	$174	
4k	1/2-Inch Thread-O-Let	3	EA	$7.00	$21	0.7	2.1	$48	$101	$2.00	$6	$128	
4l	Chem Seal	3	EA	$450.00	$1,350	1	3	$48	$144	$0.00	$0	$1,494	
4m	Pressure Switch	3	EA	$450.00	$1,350	1	3	$48	$144	$0.00	$0	$1,494	
4n	Pressure Indicator	3	EA	$50.00	$150	0.25	0.75	$48	$36	$0.00	$0	$186	
4o	Seal Water Station	3	EA	$750.00	$2,250	32	96	$48	$4,608	$0.00	$0	$6,858	
4p	**Install Flow Meters**	3	EA	$5,500.00	$16,500	16	48	$48	$2,304	$0.00	$0	$18,804	
rq	8-Inch Flanges	31	EA	$117.00	$3,627	1.412	43.772	$48	$2,101	$0.00	$0	$5,728	
4r	8-Inch Bolt and Gasket Sets	31	EA	$16.25	$504	0	0	$48	$0	$0.00	$0	$504	
5	**Install Centrate Piping-10-Inch**	200	LF	$48.00	$9,600	0.774	154.8	$48	$7,430	$0.00	$0	$17,030	Glass Lined
5a	10-Inch Flex Coupling	3	EA	$400.00	$1,200	3.2	9.6	$48	$461	$0.00	$0	$1,661	
5b	10-Inch Elbows	6	EA	$350.00	$2,100	1.333	7.998	$48	$384	$0.00	$0	$2,484	
5c	10-Inch Plug Valves	3	EA	$1,725.00	$5,175	10.909	32.727	$48	$1,571	$0.00	$0	$6,746	
5d	Connect To Existing	3	EA	$350.00	$1,050	4	12	$48	$576	$0.00	$0	$1,626	
5e	10-Inch Flanges	12	EA	$185.00	$2,220	1.714	20.568	$48	$987	$0.00	$0	$3,207	
5f	10-Inch Bolt and Gasket	12	EA	$33.50	$402	0	0	$48	$0	$0.00	$0	$402	
6	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
7	**3-Inch C3HP Piping**	120	LF	$10.30	$1,236	0.296	35.52	$48	$1,705	$0.00	$0	$2,941	
7a	3-Inch Elbows	20	EA	$14.00	$280	1.455	29.1	$48	$1,397	$0.00	$0	$1,677	

7b	3-Inch Tees	10	EA	$26.00	$260	2.286	22.86	$48	$1,097	$0.00	$0	$1,357	
7d	3-Inch Ball Valves	8	EA	$95.00	$760	2	16	$48	$768	$0.00	$0	$1,528	
7e	3-Inch Motorized Valves	3	EA	$633.00	$1,899	4	12	$48	$576	$0.00	$0	$2,475	
7f	1-Inch C3HP Piping	150	LF	$4.00	$600	0.15	22.5	$48	$1,080	$0.00	$0	$1,680	
7g	1-Inch Elbows	10	EA	$7.00	$70	0.5	5	$48	$240	$0.00	$0	$310	
7h	1-Inch Flushing Connections	6	EA	$100.00	$600	4	24	$48	$1,152	$0.00	$0	$1,752	
8	**Extend 3-Inch POL Piping**	200	LF	$5.45	$1,090	0.32	64	$48	$3,072	$0.00	$0	$4,162	
8a	3-Inch Valves	6	EA	$195.00	$1,170	1	6	$48	$288	$0.00	$0	$1,458	
8b	3-Inch Elbows	24	EA	$9.25	$222	1.142	27.408	$48	$1,316	$0.00	$0	$1,538	
8c	3-Inch Tees	12	EA	$17.00	$204	1.778	21.336	$48	$1,024	$0.00	$0	$1,228	
8d	3-Inch Flow Meter	3	EA	$3,500.00	$10,500	3	9	$48	$432	$0.00	$0	$10,932	
8e	3-Inch Motor Oper. Valve	3	EA	$1,200.00	$3,600	5	15	$48	$720	$0.00	$0	$4,320	
8f	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
8g	**Install new Polymer Pump**	3	EA	$5,500.00	$16,500	32	96	$48	$4,608	$75.00	$225	$21,333	
8h	Modify Pipe & Calibration	3	LS	$2,500.00	$7,500	60	180	$48	$8,640	$0.00	$0	$16,140	
8i	Equp. Bases	3	EA	$400.00	$1,200	0	0	$35	$0	$0.00	$0	$1,200	
8i	**Install VFD**	3	EA	$4,500.00	$13,500	20	60	$48	$2,880	$0.00	$0	$16,380	
9	**Modify FA Piping**	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
9a	36-Inch FA Piping	150	LF	$82.50	$12,375	1.165	174.75	$48	$8,388	$0.00	$0	$20,763	
9b	36-Inch Tees	9	EA	$565.00	$5,085	10.573	95.157	$48	$4,568	$0.00	$0	$9,653	
9a	24-Inch FA Piping	80	LF	$56.50	$4,520	0.649	51.92	$48	$2,492	$0.00	$0	$7,012	
9b	24-Inch FA Elbow	2	EA	$415.00	$830	4.898	9.796	$48	$470	$0.00	$0	$1,300	
9c	24-Inch FA Tee	4	EA	$300.00	$1,200	6.936	27.744	$48	$1,332	$0.00	$0	$2,532	
9d	12-Inch FA Piping	120	LF	$24.00	$2,880	0.235	28.2	$48	$1,354	$0.00	$0	$4,234	
9e	12-Inch Elbows	16	LF	$133.00	$2,128	2.462	39.392	$48	$1,891	$0.00	$0	$4,019	
9f	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
9h	12-Inch Damper	8	EA	$266.00	$2,128	2.222	17.776	$48	$853	$0.00	$0	$2,981	
10	1-Inch Service Air Piping Allowance	1	LS	$2,000.00	$2,000	0	0	$48	$0	$0.00	$0	$2,000	
11	1-Inch Instrument Air Pipe Allowance	1	LS	$2,000.00	$2,000	0	0	$48	$0	$0.00	$0	$2,000	
12	Basement Plumbing Allowance	1	LS	$2,500.00	$2,500	0	0	$48	$0	$0.00	$0	$2,500	
13	Main Level Plumbing Allowance	1	LS	$4,000.00	$4,000	0	0	$48	$0	$0.00	$0	$4,000	
14	Rain Water Piping Allowance	1	LS	$1,000.00	$1,000	0	0	$48	$0	$0.00	$0	$1,000	
15	**Building Crane**	2	EA	$28,100.00	$56,200	43	86	$48	$4,128	$200.00	$400	$60,728	
16	HVAC Modifications @ Basement	1	LS	$15,000.00	$15,000	0	0	$48	$0	$0.00	$0	$15,000	
16a	HVAC Modifications to Main Level	2,700	SF	$11.00	$29,700	0	0	$48	$0	$0.00	$0	$29,700	
17	**Truck Scale Modifications**	2	EA	$20,000.00	$40,000	0	0	$48	$0	$0.00	$0	$40,000	
18	Misc. Centrifuge Elements	3	EA	$4,000.00	$12,000	100	300	$48	$14,400	$500.00	$1,500	$27,900	
Subtotal Centifuges					**$3,384,291**		**5376.471**		**$257,525**		**$10,121**	**$3,651,937**	**$3,651,937**

Yard Modifications

1	Demolish Asphalt and Curbs	1	LS	$750.00	$750	0	0	$35	$0	$0.00	$0	$750	
2	Remove Fuel Pumps	1	EA	$800.00	$800	0	0	$35	$0	$0.00	$0	$800	
3	Concrete Island	5	CY	$300.00	$1,500	0	0	$35	$0	$0.00	$0	$1,500	
3a	Drill/Set Dowel Bars	1	LS	$2,000.00	$2,000	0	0	$35	$0	$0.00	$0	$2,000	
3b	Guard Posts	4	EA	$150.00	$600	0	0	$35	$0	$0.00	$0	$600	
3c	Set Fuel Pump	1	EA	$900.00	$900	0	0	$35	$0	$0.00	$0	$900	
3d	Fuel Pump Piping	1	LS	$3,500.00	$3,500	0	0	$35	$0	$0.00	$0	$3,500	
4	Modify Water Piping	1	LS	$3,500.00	$3,500	0	0	$35	$0	$0.00	$0	$3,500	
5	Modify Vent Piping	1	LS	$2,500.00	$2,500	0	0	$35	$0	$0.00	$0	$2,500	
6	Modify Trench Drain	1	LS	$2,500.00	$2,500	0	0	$35	$0	$0.00	$0	$2,500	
7	Relocate Yard Hydrant	1	EA	$1,200.00	$1,200	0	0	$35	$0	$0.00	$0	$1,200	
8	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
Subtotal Yard Modifications					**$19,750**		**0**		**$0**		**$0**	**$19,750**	**$19,750**

Provide Transformer Substation, Structural Allowances, Sequence and Miscellaneous

1	MCC Room Upgrade	1	LS	$25,000.00	$25,000		0	$40	$0	$0.00	$0	$25,000	
1a	HVAC In Modified MCC Room Allowance	1	LS	$5,000.00	$5,000	0	0	$40	$0	$0.00	$0	$5,000	
2	Structural Allowance	1	LS	$275,000.00	$275,000		0	$40	$0	$0.00	$0	$275,000	
3	Transformer, Misc.	1	LS	$0.00	$0		0	$40	$0	$0.00	$0	$0	
3a	**New Transformers, 1000KVA**	2	EA	$28,000.00	$56,000	67	134	$40	$5,360	$600.00	$1,200	$62,560	Note 3
3b	New Conductor, Solids Bldg to Xfmr.	5,000	LF	$6.25	$31,250	0.039	195	$40	$7,800	$0.00	$0	$39,050	
3c	New Conductor Xfrm to SwGear/MCC	4,000	LF	$6.25	$25,000	0.039	156	$40	$6,240	$0.00	$0	$31,240	
3d	Transformer Pad & Enclosure	1	LS	$20,000.00	$20,000	0	0	$40	$0	$0.00	$0	$20,000	
3e	New Swichgear	1	UNIT	$25,000.00	$25,000	0	0	$40	$0	$0.00	$0	$25,000	
4	**New Main Control Panel/PLC**	1	LS	$150,000.00	$150,000	0	0	$40	$0	$0.00	$0	$150,000	
4a	Instrumentation Control Diagrams	1	LS	$125,000.00	$125,000	0	0	$40	$0	$0.00	$0	$125,000	
5	Construction Sequence Allowance	1	LS	$75,000.00	$75,000		0	$40	$0	$0.00	$0	$75,000	
6	Struvite Control System Allowance	1	LS	$30,000.00	$30,000	0	0	$40	$0	$0.00	$0	$30,000	
6	Yard Modification	1	LS	$3,500.00	$3,500		0	$40	$0	$0.00	$0	$3,500	
Subtotal					**$845,750**		**485**		**$19,400**		**$1,200**	**$866,350**	**$866,350**

Base Cost for Centrifuges				$5,661,153
Electrical Cost Allowance	20.00%		$4,538,037	$907,607
Subtotal Base Cost				$6,568,760
Equipment Contingency	5.00%	Note 1	$2,100,000	$105,000
Subtotal				$6,673,760
Estimator's Contingecy	25.00%	Note 2	$4,468,760	$1,117,190
Subtotal				$7,790,950
Testing/Commissioning	2.00%			$155,819
Subtotal				$7,946,769
Overhead & Profit	15.00%			$1,192,015
Subtotal				$9,138,784
Bonds/Insur./Mobilization	4.00%			$365,551
Subtotal				$9,504,336
Wa State Sales Tax	8.60%			$817,373
Subtotal				$10,321,709
Allied Cost	35.00%			$3,612,598
Subtotal				$13,934,307
Mid Point of Construction, 2004	9.30%			$1,295,891
TOTAL ESTIMATED CAPITAL COST				$15,230,197

Note 1---Contingency applied to equipment cost for 3 centrifuges

Note 2---Contingency applied to all elements excluding equipment cost for 3 centrifuges

Note 3---Power requirements to be sized for both temp. operation of sludge dewatering and startup for new centrifuges. This assumes that the existing MCC is available for modification w/belt presses down.

Note 4---Centrifuge cost based on Alph-Laval DS706 bid price in Oregon, June, 2001.

ALTERNATIVE 1
South Plant

REPLACE 8 BFP'S WITH 3 CENTRIDRY UNITS

REVISED

Prepared By Brown and Caldwell, February 12, 2002

Preliminary Cost Estimate

Demolition of Existing Belt Filter Presses To be removed prior to installation of Centridry Units

				Material Cost		Labor				Equipment		
Item	**Description**	**Quantity**	**Unit**	**Unit Cost**	**Amount**	**Labor Hr.**	**Total Hr.**	**Rate**	**Amount**	**Unit Cost**	**Amount**	**Total**
1	Remove Roof Hatch	6	EA	$250.00	$1,500	16	96	$48	$4,608	$300.00	$1,800	$7,908
2	**Remove Portion of FA System**	1	LS	$0.00	$0	0	0	$48	$0	$0.00	$0	$0
2a	Remove Hood and Cables	8	EA	$0.00	$0	8	64	$48	$3,072	$50.00	$400	$3,472
2b	Remove 54-Inch FA Pipe	50	LF	$0.00	$0	1	50	$48	$2,400	$0.00	$0	$2,400
2c	Remove 20-Inch FA Pipe	20	LF	$0.00	$0	0.3	6	$48	$288	$0.00	$0	$288
2d	Remove 30-Inch FA Pipe	36	LF	$0.00	$0	0.5	18	$48	$864	$0.00	$0	$864
2e	Remove 24-Inch FA Pipe	24	LF	$0.00	$0	0.35	8.4	$48	$403	$0.00	$0	$403
2f	R3move 24-Inch Elbows	8	EA	$0.00	$0	1	8	$48	$384	$0.00	$0	$384
3	**Remove Belt Filter Presses**	8	EA	$500.00	$4,000	100	800	$48	$38,400	$2,000.00	$16,000	$58,400
3a	Cut Bolts and Patch Surface	192	EA	$3.00	$576	0.35	67.2	$35	$2,352	$0.00	$0	$2,928
3b	Remove Piping Connections	8	EA	$50.00	$400	16	128	$48	$6,144	$75.00	$600	$7,144
3c	Remove Structural Support System	8	EA	$0.00	$0	32	256	$35	$8,960	$250.00	$2,000	$10,960
3d	Remove Bridge Section	4	EA	$0.00	$0	12	48	$35	$1,680	$75.00	$300	$1,980
3e	Remove BS Piping to Floor	350	LF	$0.00	$0	0.16	56	$48	$2,688	$0.25	$88	$2,776
3f	Salvage Flow Elements	8	EA	$25.00	$200	2	16	$48	$768	$0.00	$0	$968
4	**Remove Feed Pump**	8	EA	$50.00	$400	16	128	$48	$6,144	$150.00	$1,200	$7,744
4a	Break Out Concrete Base	8	EA	$0.00	$0	16	128	$35	$4,480	$150.00	$1,200	$5,680
4b	Cut Bolts/Rebar	128	EA	$0.00	$0	0.25	32	$35	$1,120	$0.00	$0	$1,120
4c	Isolate Seal Water Piping	8	EA	$25.00	$200	1	8	$48	$384	$0.00	$0	$584
4d	Remove Exist. Polymer Pump	8	EA	$50.00	$400	6	48	$48	$2,304	$75.00	$600	$3,304
5	**Remove Washwater Pump**	8	EA	$50.00	$400	12	96	$48	$4,608	$100.00	$800	$5,808
5a	Break Out Concrete Base	8	EA	$0.00	$0	16	128	$35	$4,480	$150.00	$1,200	$5,680
5b	Remove Piping	8	EA	$0.00	$0	16	128	$48	$6,144	$100.00	$800	$6,944
5c	Isolate Seal Water Piping	8	EA	$25.00	$200	1	8	$48	$384	$0.00	$0	$584
6	Demo Piping	1	LS	$0.00	$0	0	0	$35	$0	$0.00	$0	$0
6a	Cap 4-Inch POL Piping	8	EA	$4.00	$32	0.5	4	$48	$192	$0.00	$0	$224
6b	Remove 6-Inch Filtrate Piping	500	LF	$0.00	$0	0.16	80	$35	$2,800	$0.00	$0	$2,800
6c	Cap Unused Pipe Penetrations	13	EA	$50.00	$650	1	13	$48	$624	$0.50	$7	$1,281
6d	Remove 6-Inch BS Piping	450	LF	$0.00	$0	0.16	72	$35	$2,520	$0.50	$225	$2,745
6e	Remove Portion of 10-Inch BS	64	LF	$0.00	$0	0.16	10.24	$35	$358	$0.50	$32	$390
6f	Remove Drain Piping	8	EA	$0.00	$0	4	32	$35	$1,120	$0.00	$0	$1,120
7	**Remove MCC CB's**	16	EA	$0.00	$0	8	128	$48	$6,144	$0.00	$0	$6,144
7a	Remove Conductors	8	EA	$0.00	$0	40	320	$48	$15,360	$75.00	$600	$15,960
7b	Remove BFP Control Panel	8	EA	$200.00	$1,600	40	320	$48	$15,360	$150.00	$1,200	$18,160
8	**Remove Conveyors**	168	LF	$0.00	$0	0.5	84	$35	$2,940	$1.50	$252	$3,192
8a	Cut Anchor Bolts	85	EA	$0.00	$0	0.05	4.25	$35	$149	$0.00	$0	$149
8b	Epoxy Patch Anchor Bolts	85	EA	$0.50	$43	0.05	4.25	$35	$149	$0.00	$0	$191
9	**Break Out Conc. Filtrate Contain.**	43	CY	$0.00	$0	6	258	$35	$9,030	$25.00	$1,075	$10,105
9a	Sandblast Conc. Surface	2,300	SF	$0.21	$483	0.022	50.6	$35	$1,771	$0.05	$115	$2,369
9b	Restore Floor Surface	2,300	SF	$3.00	$6,900	0	0	$35	$0	$0.00	$0	$6,900
9c	Remove Conc. Curbs	12	CY	$0.00	$0	4	48	$35	$1,680	$25.00	$300	$1,980
9d	Cut Rebar @ Floor	624	EA	$0.00	$0	0.05	31.2	$35	$1,092	$0.00	$0	$1,092

9e	Patch Rebar @ Floor	624	EA	$0.50	$312	0.05	31.2	$35	$1,092	$0.00	$0	$1,404	
9f	**Sandblast Conc. Surface**	312	SF	$0.21	$66	0.022	6.864	$35	$240	$0.05	$16	$321	
9g	Restore Floor Surface	312	SF	$3.00	$936	0	0	$35	$0	$0.00	$0	$936	
10	**Remove Grinders**	2	EA	$0.00	$0	16	32	$35	$1,120	$100.00	$200	$1,320	
10a	Remove Control Panels	2	EA	$0.00	$0	16	32	$45	$1,440	$50.00	$100	$1,540	
11	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
12	Replace/Seal Roof Hatches	6	EA	$1,500.00	$9,000	16	96	$35	$3,360	$300.00	$1,800	$14,160	
Subtotal Initial Demolition					**$28,297**		**3983.204**		**$171,600**		**$32,909**	**$232,806**	**$232,806**

Install 3 Centridry Units

1	**Construct Concrete Pedistals**	3	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
1a	Drill Holes for Concrete Piers	120	EA	$2.50	$300	0.25	30	$35	$1,050	$0.00	$0	$1,350	
1b	Epoxy Dowel Bars	120	EA	$2.00	$240	0.083	9.96	$35	$349	$0.00	$0	$589	
1c	Concrete Piers	15	CY	$450.00	$6,750	0	0	$35	$0	$20.00	$300	$7,050	
1d	Drill Holes for Walkway Support	250	EA	$2.50	$625	0.25	62.5	$35	$2,188	$0.00	$0	$2,813	
1e	S.S. Anchor Bolts	250	EA	$10.00	$2,500	0.083	20.75	$35	$726	$0.00	$0	$3,226	
1f	Steel Columns	420	LF	$11.20	$4,704	0.0805	33.81	$48	$1,623	$1.45	$609	$6,936	
1g	Weld Beam Connections	300	LF	$0.41	$123	0.1	30	$48	$1,440	$1.03	$309	$1,872	
1h	Horizontal Steel Beams	520	LF	$18.33	$9,532	0.09	46.8	$48	$2,246	$1.56	$811	$12,589	
1i	Post tops 4" X 4" X 1/4"	100	LBS	$1.00	$100	0.3	30	$48	$1,440	$0.00	$0	$1,540	
1j	Weld Cap to Post Top	80	LF	$0.41	$33	0.1	8	$48	$384	$1.03	$82	$499	
1k	Flat Bar X 1/4-Inch	435	LBS	$0.50	$218	0.3	130.5	$48	$6,264	$0.00	$0	$6,482	
1l	Weld Flat Bar to Beams	250	LF	$0.41	$103	0.1	25	$48	$1,200	$1.03	$258	$1,560	
1m	Fiberglass Grating	1,300	SF	$16.60	$21,580	0.04	52	$35	$1,820	$0.00	$0	$23,400	
1n	Hand Rail	450	LF	$26.00	$11,700	0.234	105.3	$35	$3,686	$0.00	$0	$15,386	
1o	Hand Rail Base Plate	50	EA	$15.00	$750	1	50	$35	$1,750	$0.00	$0	$2,500	
1p	Steel Stairs	2	EA	$4,500.00	$9,000	40	80	$35	$2,800	$0.00	$0	$11,800	
1q	Containment Curbs	8	CY	$450.00	$3,600	0	0	$35	$0	$20.00	$160	$3,760	
1r	Splash Slab	25	CY	$300.00	$7,500	0	0	$35	$0	$20.00	$500	$8,000	
1s	Coating	900	SF	$3.50	$3,150	0	0	$35	$0	$0.00	$0	$3,150	
1t	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
2	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
2a	**Install Centridry Centrifuge Sys.**	1	EA	$7,084,600.00	$7,084,600	0	0	$48	$0	$7,500.00	$7,500	$7,092,100	Note 3
2b	**Support Centridry Exhaust Fan**	3	EA	$500.00	$1,500	0	0	$48	$0	$0.00	$0	$1,500	Note 3
2c	**Support Centridry Scrubber**	3	EA	$800.00	$2,400	0	0	$48	$0	$0.00	$0	$2,400	Note 3
2d	**Support Venturi Scrubber**	3	EA	$800.00	$2,400	0	0	$48	$0	$0.00	$0	$2,400	Note 3
2e	**Support Burner Unit**	3	EA	$2,500.00	$7,500	0	0	$48	$0	$0.00	$0	$7,500	Note 3
2f	Roof Penetration for Stack	3	EA	$1,000.00	$3,000	0	0	$48	$0	$0.00	$0	$3,000	
2g	**Support Scrubber Water Pump**	3	EA	$400.00	$1,200	0	0	$48	$0	$0.00	$0	$1,200	Note 3
2h	**Support Circ. Fan**	3	EA	$500.00	$1,500	0	0	$48	$0	$0.00	$0	$1,500	
2i	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
2j	**Cyclone Screw Conveyor (3 EA)**	3	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	Note 3
2k	**No./So. Screw Conveyor (1 EA)**	1	EA	$157,000.00	$157,000	90	90	$48	$4,320	$5.00	$5	$161,325	
2l	**Truck Load Conveyor (2 EA)**	2	EA	$106,000.00	$212,000	61	122	$48	$5,856	$5.00	$10	$217,866	
2m	Modify Drop Chutes	4	EA	$1,000.00	$4,000	8	32	$48	$1,536	$0.00	$0	$5,536	
2n	New Drop Chutes	2	EA	$7,500.00	$15,000	60	120	$48	$5,760	$0.00	$0	$20,760	
3	**Install Sludge Feed Pump**	3	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	Note 3
3a	Drill Holes for Dowels	54	EA	$2.50	$135	0.25	13.5	$35	$473	$0.00	$0	$608	
3b	Install Dowels	54	EA	$2.50	$135	0.083	4.482	$35	$157	$0.00	$0	$292	
3ba	Equipment Pad	3	EA	$500.00	$1,500	0	0	$35	$0	$0.00	$0	$1,500	
3c	**Provide VFD**	3	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	Note 3
3d	10-Inch Suction Header	70	LF	$37.50	$2,625	0.774	54.18	$48	$2,601	$0.00	$0	$5,226	
3e	**New Grinder**	3	EA	$25,000.00	$75,000	40	120	$48	$5,760	$50.00	$150	$80,910	
3f	10-Inch X 8-Inch Reducers	6	EA	$201.00	$1,206	1.2	7.2	$48	$346	$0.00	$0	$1,552	
3g	8-Inch Piping	60	LF	$25.00	$1,500	0.649	38.94	$48	$1,869	$0.00	$0	$3,369	

3h	8-Inch Elbows	10	EA	$157.00	$1,570	1.143	11.43	$48	$549	$0.00	$0	$2,119	
3i	8-Inch Tees	9	EA	$268.00	$2,412	1.714	15.426	$48	$740	$0.00	$0	$3,152	
3j	8-Inch Plug Valves	12	EA	$1,175.00	$14,100	9.6	115.2	$48	$5,530	$0.00	$0	$19,630	
3k	8-Inch flex Coupling	6	EA	$299.00	$1,794	2.963	17.778	$48	$853	$0.00	$0	$2,647	
3l	8-Inch flanges	28	EA	$117.00	$3,276	1.412	39.536	$48	$1,898	$0.00	$0	$5,174	
3m	8-Inch Bolt and Gasket Sets	28	EA	$16.25	$455	0	0	$48	$0	$0.00	$0	$455	
3n	10-Inch Tees	3	EA	$555.00	$1,665	2	6	$48	$288	$0.00	$0	$1,953	
3o	10-Inch Elbows	2	EA	$286.00	$572	1.333	2.666	$48	$128	$0.00	$0	$700	
3p	**10-Inch Suction Piping**	30	LF	$37.50	$1,125	0.774	23.22	$48	$1,115	$0.00	$0	$2,240	
3q	10-Inch Elbows	3	EA	$286.00	$858	1.333	3.999	$48	$192	$0.00	$0	$1,050	
3r	10-Inch Flex Couplings	3	EA	$400.00	$1,200	3.2	9.6	$48	$461	$0.00	$0	$1,661	
3s	1-Inch Weld-O-Let	3	EA	$8.00	$24	0.8	2.4	$48	$115	$2.50	$8	$147	
3t	1-Inch Nipple	3	EA	$1.00	$3	0.48	1.44	$48	$69	$0.00	$0	$72	
3u	Quick coupling	3	EA	$35.00	$105	0.48	1.44	$48	$69	$0.00	$0	$174	
3v	1-Inch Plug Valve	3	EA	$79.00	$237	0.571	1.713	$48	$82	$0.00	$0	$319	
3w	10-Inch Plug Valves	3	EA	$1,725.00	$5,175	10.909	32.727	$48	$1,571	$0.00	$0	$6,746	
3x	10-Inch Flanges	9	EA	$185.00	$1,665	1.714	15.426	$48	$740	$0.00	$0	$2,405	
3y	10-Inch Bolt and Gasket	9	EA	$33.50	$302	0	0	$48	$0	$0.00	$0	$302	
3z	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
4	**8-Inch Discharge Piping**	250	LF	$25.00	$6,250	0.649	162.25	$48	$7,788	$0.00	$0	$14,038	
4a	8-Inch Tee	12	EA	$268.00	$3,216	1.714	20.568	$48	$987	$0.00	$0	$4,203	
4b	8-Inch Elbows	20	EA	$157.00	$3,140	1.143	22.86	$48	$1,097	$0.00	$0	$4,237	
4c	8-Inch X 6-Inch Reducers	6	EA	$99.00	$594	1.043	6.258	$48	$300	$0.00	$0	$894	
4c	8-Inch Plug Valves	3	EA	$1,175.00	$3,525	9.6	28.8	$48	$1,382	$0.00	$0	$4,907	
4d	6-Inch Plug Valves	8	EA	$655.00	$5,240	8	64	$48	$3,072	$0.00	$0	$8,312	
4e	6-Inch Flow Meter	3	EA	$6,500.00	$19,500	16	48	$48	$2,304	$0.00	$0	$21,804	
4f	8-Inch Flex Couplings	3	EA	$299.00	$897	2.963	8.889	$48	$427	$0.00	$0	$1,324	
4g	1-Inch Weld-O-Let	3	EA	$8.00	$24	0.8	2.4	$48	$115	$2.50	$8	$147	
4h	1-Inch Nipple	3	EA	$1.00	$3	0.48	1.44	$48	$69	$0.00	$0	$72	
4i	1-Inch Plug Valve	3	EA	$79.00	$237	0.571	1.713	$48	$82	$0.00	$0	$319	
4j	1-Inch Quick Coupling	3	EA	$35.00	$105	0.48	1.44	$48	$69	$0.00	$0	$174	
4k	1/2-Inch Thread-O-Let	3	EA	$7.00	$21	0.7	2.1	$48	$101	$2.00	$6	$128	
4l	Chem Seal	3	EA	$450.00	$1,350	1	3	$48	$144	$0.00	$0	$1,494	
4m	Pressure Switch	3	EA	$450.00	$1,350	1	3	$48	$144	$0.00	$0	$1,494	
4n	Pressure Indicator	3	EA	$50.00	$150	0.25	0.75	$48	$36	$0.00	$0	$186	
4o	Seal Water Station	3	EA	$750.00	$2,250	32	96	$48	$4,608	$0.00	$0	$6,858	
4p	**Install Flow Meters**	3	EA	$5,500.00	$16,500	16	48	$48	$2,304	$0.00	$0	$18,804	
4q	8-Inch Flanges	31	EA	$117.00	$3,627	1.412	43.772	$48	$2,101	$0.00	$0	$5,728	
4r	8-Inch Bolt and Gasket Sets	31	EA	$16.25	$504	0	0	$48	$0	$0.00	$0	$504	
5	**Install Centrate Piping-10-Inch**	200	LF	$48.00	$9,600	0.774	154.8	$48	$7,430	$0.00	$0	$17,030	Glass Lined
5a	10-Inch Flex Coupling	3	EA	$400.00	$1,200	3.2	9.6	$48	$461	$0.00	$0	$1,661	
5b	10-Inch Elbows	6	EA	$350.00	$2,100	1.333	7.998	$48	$384	$0.00	$0	$2,484	
5c	10-Inch Plug Valves	3	EA	$1,725.00	$5,175	10.909	32.727	$48	$1,571	$0.00	$0	$6,746	
5d	Connect To Existing	3	EA	$350.00	$1,050	4	12	$48	$576	$0.00	$0	$1,626	
5e	10-Inch Flanges	12	EA	$185.00	$2,220	1.714	20.568	$48	$987	$0.00	$0	$3,207	
5f	10-Inch Bolt and Gasket	12	EA	$33.50	$402	0	0	$48	$0	$0.00	$0	$402	
6	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
7	**3-Inch C3HP Piping**	120	LF	$10.30	$1,236	0.296	35.52	$48	$1,705	$0.00	$0	$2,941	
7a	3-Inch Elbows	10	EA	$14.00	$140	1.455	14.55	$48	$698	$0.00	$0	$838	
7b	3-Inch Tees	6	EA	$26.00	$156	2.286	13.716	$48	$658	$0.00	$0	$814	
7d	3-Inch Ball Valves	4	EA	$95.00	$380	2	8	$48	$384	$0.00	$0	$764	
7e	3-Inch Motorized Valves	3	EA	$633.00	$1,899	4	12	$48	$576	$0.00	$0	$2,475	
7f	1-Inch C3HP Piping	30	LF	$4.00	$120	0.15	4.5	$48	$216	$0.00	$0	$336	
7g	1-Inch Elbows	10	EA	$7.00	$70	0.5	5	$48	$240	$0.00	$0	$310	
7h	1-Inch Flushing Connections	6	EA	$100.00	$600	4	24	$48	$1,152	$0.00	$0	$1,752	
8	**Extend 3-Inch POL Piping**	150	LF	$5.45	$818	0.32	48	$48	$2,304	$0.00	$0	$3,122	
8a	3-Inch Valves	6	EA	$195.00	$1,170	1	6	$48	$288	$0.00	$0	$1,458	
8b	3-Inch Elbows	24	EA	$9.25	$222	1.142	27.408	$48	$1,316	$0.00	$0	$1,538	
8c	3-Inch Tees	12	EA	$17.00	$204	1.778	21.336	$48	$1,024	$0.00	$0	$1,228	
8d	3-Inch Flow Meter	3	EA	$3,500.00	$10,500	3	9	$48	$432	$0.00	$0	$10,932	

8e	3-Inch Motor Oper. Valve	3	EA	$1,200.00	$3,600	5	15	$48	$720	$0.00	$0	$4,320	
8f	**Install new Polymer Pump**	3	EA	$5,500.00	$16,500	32	96	$48	$4,608	$75.00	$225	$21,333	
8g	Modify Pipe & Calibration	3	LS	$2,500.00	$7,500	60	180	$48	$8,640	$0.00	$0	$16,140	
8h	**Install VFD**	3	EA	$4,500.00	$13,500	20	60	$48	$2,880	$0.00	$0	$16,380	
9	**Modify FA Piping**	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
9a	36-Inch FA Piping	100	LF	$82.50	$8,250	1.165	116.5	$48	$5,592	$0.00	$0	$13,842	
9b	36-Inch Tees	9	EA	$565.00	$5,085	10.573	95.157	$48	$4,568	$0.00	$0	$9,653	
9a	24-Inch FA Piping	40	LF	$56.50	$2,260	0.649	25.96	$48	$1,246	$0.00	$0	$3,506	
9b	24-Inch FA Elbow	2	EA	$415.00	$830	4.898	9.796	$48	$470	$0.00	$0	$1,300	
9c	24-Inch FA Tee	4	EA	$300.00	$1,200	6.936	27.744	$48	$1,332	$0.00	$0	$2,532	
9d	12-Inch FA Piping	120	LF	$24.00	$2,880	0.235	28.2	$48	$1,354	$0.00	$0	$4,234	
9e	12-Inch Elbows	16	LF	$133.00	$2,128	2.462	39.392	$48	$1,891	$0.00	$0	$4,019	
9f	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
9h	12-Inch Damper	8	EA	$266.00	$2,128	2.222	17.776	$48	$853	$0.00	$0	$2,981	
10	**Extend FA to Trailer Locations**	4	EA	$2,000.00	$8,000	0	0	$48	$0	$0.00	$0	$8,000	
11	**Bridge Crane (avg 32' span)**	2	EA	$28,100.00	$56,200	43	86	$48	$4,128	$200.00	$400	$60,728	
12	**HVAC Mods to Exist Room**	1	LS	$20,000.00	$20,000	0	0	$48	$0	$0.00	$0	$20,000	
13	**Provide 1-Inch HP Sludge Gas**	800	LF	$1.73	$1,384	0.151	120.8	$48	$5,798	$0.00	$0	$7,182	
13a	Pressure Reducers	2	EA	$750.00	$1,500	2	4	$48	$192	$0.00	$0	$1,692	
13b	Connection @ Plant HP Gas	1	LS	$500.00	$500	0	0	$48	$0	$0.00	$0	$500	
14	**Provide 1-Inch Natural Gas**	800	LF	$1.73	$1,384	0.151	120.8	$48	$5,798	$0.00	$0	$7,182	
14a	Gas Meter	1	EA	$150.00	$150	1	1	$48	$48	$0.00	$0	$198	
14b	Pressure Reducers	2	EA	$750.00	$1,500	2	4	$48	$192	$0.00	$0	$1,692	
14c	Connection @ NG Main	1	LS	$1,000.00	$1,000	0	0	$0	$0	$48.00	$48	$1,048	
15	**Truck Scale Modifications**	2	EA	$20,000.00	$40,000	0	0	$48	$0	$0.00	$0	$40,000	
16	Hot Air Duct Wall Penetration	3	EA	$1,000.00	$3,000	0	0	$35	$0	$0.00	$0	$3,000	
17	Misc. Elements @ Centridry	3	EA	$4,000.00	$12,000	100	300	$48	$14,400	$500.00	$1,500	$27,900	
Subtotal Centifuges					$8,013,468		3997.011		$186,286		$12,888	$8,212,642	$8,212,642

Extend Existing Dewatering Building South to Facilitate Centridry Cyclone Unit

31 feet X 58 feet

1	Asphalt Removal	320	SY		$0		0	$35	$0		$0	$0
1a	Site Excavation	380	CY	$0.00	$0	3.75	1425	$35	$49,875	$0.00	$0	$49,875
1b	Material Disposal	380	CY	$0.00	$0	0	0	$35	$0	$8.00	$3,040	$3,040
1c	Structural Fill	170	CY	$12.00	$2,040	0.16	27.2	$35	$952	$1.50	$255	$3,247
1d	Base Rock	42	CY	$15.00	$630	0.16	6.72	$35	$235	$1.50	$63	$928
1e	Vapor Barrier	255	SY	$1.50	$383	0	0	$35	$0	$0.00	$0	$383
2	Slab On Grade @ El 111	170	CY	$350.00	$59,500	0	0	$35	$0	$20.00	$3,400	$62,900
3	Ground Floor Concrete Walls	61	CY	$400.00	$24,400	0	0	$35	$0	$20.00	$1,220	$25,620
3a	Ground Floor H Columns	72	LF	$44.00	$3,168	0.054	3.888	$40	$156	$1.25	$90	$3,414
3b	H Column Encasement	3	CY	$475.00	$1,425	0	0	$35	$0	$20.00	$60	$1,485
3c	Perimeter Steel Beams	246	LF	$88.00	$21,648	0.108	26.568	$40	$1,063	$1.50	$369	$23,080
3d	Perimeter Beam Encasement	28	CY	$475.00	$13,300	0	0	$35	$0	$20.00	$560	$13,860
3e	Chip Out Existing Columns	3	EA	$1,500.00	$4,500	0	0	$35	$0	$0.00	$0	$4,500
3f	Steel Column Attachment	3	EA	$750.00	$2,250	0	0	$35	$0	$0.00	$0	$2,250
4	Second Floor @ El 126	66	CY	$450.00	$29,700	0	0	$35	$0	$20.00	$1,320	$31,020
4a	Second Floor H Columns	132	LF	$44.00	$5,808	0.054	7.128	$40	$285	$1.25	$165	$6,258
4b	H Column Encasement	11	CY	$475.00	$5,225	0	0	$35	$0	$20.00	$220	$5,445
4c	Perimeter Steel Beams	246	LF	$44.00	$10,824	0.054	13.284	$40	$531	$1.25	$308	$11,663
4d	Perimeter Beam Encasement	28	CY	$475.00	$13,300	0	0	$35	$0	$20.00	$560	$13,860
5	Roof Slab @ El 150	45	CY	$450.00	$20,250	0	0	$35	$0	$20.00	$900	$21,150
5a	Cants	178	LF	$2.03	$361	0.025	4.45	$35	$156	$0.00	$0	$517
5b	3-Inch Roof Insulation	1,800	SF	$3.12	$5,616	0.011	19.8	$35	$693	$0.00	$0	$6,309
5c	4-Ply Built Up Roofing	1,800	SF	$0.64	$1,152	0.028	50.4	$35	$1,764	$0.16	$288	$3,204
5d	Roof Drains	2	EA	$100.00	$200	1	2	$40	$80	$0.00	$0	$280
5e	Scuppers	2	EA	$50.00	$100	1	2	$35	$70	$0.00	$0	$170

5f	Roof Gravel Cover	1,800	SF	$0.38	$684	0.002	3.6	$35	$126	$0.14	$252	$1,062	
6	Precast Wall Panels	3,000	SF	$11.50	$34,500	0.04	120	$35	$4,200	$1.00	$3,000	$41,700	
6a	Panel Seimic Work	1	LS	$25,000.00	$25,000	0	0	$35	$0	$0.00	$0	$25,000	
7	New Replacement Truck Bay Doors	4	EA	$15,800.00	$63,200	48	192	$35	$6,720	$1,200.00	$4,800	$74,720	
7a	Double Man Door	2	EA	$1,500.00	$3,000	14	28	$35	$980	$0.00	$0	$3,980	
8	Remove Panel At Truck Bay	1	EA	$0.00	$0	32	32	$35	$1,120	$500.00	$500	$1,620	
9	Saw Cut for Two Doors, 2nd Level	2	EA	$300.00	$600	0	0	$35	$0	$0.00	$0	$600	
9a	Man Doors	2	EA	$1,000.00	$2,000	8	16	$35	$560	$0.00	$0	$2,560	
10	**Remove Precast Pnl @ Elev 126**	1,276	SF	$0.00	$0	0.25	319	$35	$11,165	$2.36	$3,011	$14,176	
10a	Saw Cut Curb Wall	58	LF	$3.22	$187	0.805	46.69	$48	$2,241	$24.75	$1,436	$3,863	
10b	Demo Curb Wall	1	CY	$0.00	$0	27	27	$35	$945	$95.00	$95	$1,040	
10c	Bush Surface	58	SF	$0.03	$2	0.074	4.292	$35	$150	$0.27	$16	$168	
10d	Patch Floor Surface @ Old Curb Line	58	SF	$4.00	$232	0	0	$35	$0	$0.00	$0	$232	
10e	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
11	**Acoustical Wall Treatment @ Elev 126**	4,300	SF	$6.00	$25,800	0.052	223.6	$35	$7,826	$0.10	$430	$34,056	
12	**Line Exist Filtrate Sump**	900	SF	$20.00	$18,000	0	0	$35	$0	$0.00	$0	$18,000	
12a	By Pass Pump & Storage Allowance	1	LS	$0.00	$0	0	0	$35	$0	$15,000.00	$15,000	$15,000	
13	Floor Coating	3,600	SF	$3.50	$12,600	0	0	$35	$0	$0.00	$0	$12,600	
14	Coat Interior Concrete Walls	1,800	SF	$0.20	$360	0.015	27	$35	$945	$0.10	$180	$1,485	
15	Equipment & Pipe Coating Allowance	1	LS	$35,000.00	$35,000	0	0	$35	$0	$0.00	$0	$35,000	
16	Scrubber Wall Penetration	2	EA	$500.00	$1,000	16	32	$45	$1,440	$150.00	$300	$2,740	
Subtotal Building Extention					**$447,944**		**2659.62**		**$94,278**		**$41,837**	**$584,059**	**$584,059**

Extend Truck Bay to East for Additional Scales and Extension of Conveyor over Bay

18 fee X 45 feet

1	Site Excavation	265	CY	$0.00	$0	3.75	993.75	$35	$34,781	$0.00	$0	$34,781
1a	Material Disposal	265	CY	$0.00	$0	0	0	$35	$0	$8.00	$2,120	$2,120
1b	Structural Fill	130	CY	$12.00	$1,560	0.16	20.8	$35	$728	$1.50	$195	$2,483
1c	Base Rock	15	CY	$15.00	$225	0.16	2.4	$35	$84	$1.50	$23	$332
1d	Vapor Barrier	100	SY	$1.50	$150	0	0	$35	$0	$0.00	$0	$150
2	Slab On Grade for Truck Scales	40	CY	$350.00	$14,000	0	0	$35	$0	$20.00	$800	$14,800
2a	Extend Center wall section btw bays	18	CY	$400.00	$7,200	0	0	$35	$0	$20.00	$360	$7,560
2b	Extend side wall sections north and south	24	CY	$400.00	$9,600	0	0	$35	$0	$20.00	$480	$10,080
2c	Extend Cant. One side only	16	CY	$400.00	$6,400	0	0	$35	$0	$20.00	$320	$6,720
2d	Extend Slab North of Truck Bays	20	CY	$350.00	$7,000	0	0	$35	$0	$20.00	$400	$7,400
2e	Drill Holes Existing Slab	120	EA	$2.00	$240	0.25	30	$35	$1,050	$0.00	$0	$1,290
2f	Set Dowel Bars Existing Slab	120	EA	$1.50	$180	0.1	12	$35	$420	$0.00	$0	$600
2g	East End Wall	49	CY	$350.00	$17,150	0	0	$35	$0	$20.00	$980	$18,130
3	Ground Floor H Columns (3 ea)	36	LF	$44.00	$1,584	0.054	1.944	$40	$78	$1.25	$45	$1,707
3a	H Column Encasement	3.5	CY	$475.00	$1,663	0	0	$35	$0	$20.00	$70	$1,733
3b	Perimeter Steel Beams W24X55 @ El 126	70	LF	$37.00	$2,590	0.072	5.04	$40	$202	$1.36	$95	$2,887
3c	Perimeter Steel Beams W10 X33 @ El 126	51	LF	$22.00	$1,122	0.102	5.202	$40	$208	$2.58	$132	$1,462
3d	Beam to Column Attachment	10	EA	$150.00	$1,500	2	20	$40	$800	$10.00	$100	$2,400
3e	Perimeter Beam Encasement	16	CY	$475.00	$7,600	0	0	$35	$0	$20.00	$320	$7,920
3f	Chip Out Existing Columns	3	EA	$1,500.00	$4,500	0	0	$35	$0	$0.00	$0	$4,500
3g	Steel Column Attachment	3	EA	$750.00	$2,250	0	0	$35	$0	$0.00	$0	$2,250
3h	Precast Curb Wall @ Perimeter	3	CY	$400.00	$1,200	0	0	$35	$0	$20.00	$60	$1,260
4	2nd Floor Slab @ El 126	30	CY	$450.00	$13,500	0	0	$35	$0	$20.00	$600	$14,100
4a	2nd Floor H Columns (3 ea)	36	LF	$44.00	$1,584	0.054	1.944	$40	$78	$1.25	$45	$1,707
4b	H Column Encasement	3.5	CY	$475.00	$1,663	0	0	$35	$0	$20.00	$70	$1,733
4c	Perimeter Steel Beams W24X55 @ El 126	70	LF	$37.00	$2,590	0.072	5.04	$40	$202	$1.36	$95	$2,887
4d	Perimeter Steel Beams W10 X33 @ El 126	51	LF	$22.00	$1,122	0.102	5.202	$40	$208	$2.58	$132	$1,462
4e	Beam to Column Attachment	10	EA	$150.00	$1,500	2	20	$40	$800	$10.00	$100	$2,400
4f	Perimeter Beam Encasement	16	CY	$475.00	$7,600	0	0	$35	$0	$20.00	$320	$7,920
4g	Chip Out Existing Columns	3	EA	$1,500.00	$4,500	0	0	$35	$0	$0.00	$0	$4,500
4h	Steel Column Attachment	3	EA	$750.00	$2,250	0	0	$35	$0	$0.00	$0	$2,250
4i	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0

5	Roof Slab @ El 126	20	CY	$450.00	$9,000	0	0	$35	$0	$20.00	$400	$9,400	
5a	Cants	126	LF	$2.03	$256	0.025	3.15	$35	$110	$0.00	$0	$366	
5b	3-Inch Roof Insulation	810	SF	$3.12	$2,527	0.011	8.91	$35	$312	$0.00	$0	$2,839	
5c	4-Ply Built Up Roofing	810	SF	$0.64	$518	0.028	22.68	$35	$794	$0.16	$130	$1,442	
5d	Roof Drains	2	EA	$100.00	$200	1	2	$40	$80	$0.00	$0	$280	
5e	Scuppers	2	EA	$50.00	$100	1	2	$35	$70	$0.00	$0	$170	
5f	Roof Gravel Cover	810	SF	$0.38	$308	0.002	1.62	$35	$57	$0.14	$113	$478	
6	Precast Wall Panels	1,400	SF	$11.50	$16,100	0.04	56	$35	$1,960	$1.00	$1,400	$19,460	
6a	Panel Seimic Work	1	LS	$8,000.00	$8,000	0	0	$35	$0	$0.00	$0	$8,000	
6b	Double Man Door	1	EA	$1,500.00	$1,500	14	14	$35	$490	$0.00	$0	$1,990	
7	Floor Coating	1,620	SF	$3.50	$5,670	0	0	$35	$0	$0.00	$0	$5,670	
7a	Coat Interior Concrete Walls/Ceiling	1,000	SF	$0.20	$200	0.015	15	$35	$525	$0.10	$100	$825	
8	Expansion Joint Material 1" X 24"	126	SF	$1.40	$176	0.054	6.804	$35	$238	$0.00	$0	$415	
9	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
Subtotal Truck Bay Structural Expansion					**$168,578**		**1255.486**		**$44,274**		**$10,004**	**$222,856**	**$222,856**

Mechanical in Extended Building Section 31 feet X 58 feet

1	**Equipment Pad, Centridry Cyclone**	3	EA	$1,500.00	$4,500	0	0	$35	$0	$0.00	$0	$4,500	Note 3
2	Extend HVAC System (sf basis)	1	LS	$39,000.00	$39,000	0	0	$48	$0	$0.00	$0	$39,000	
3	Extend 36-Inch FA Piping	65	LF	$82.50	$5,363	1.165	75.725	$48	$3,635	$0.00	$0	$8,997	
3a	12-Inch FA Piping	75	LF	$56.50	$4,238	0.649	48.675	$48	$2,336	$0.00	$0	$6,574	
4	Extend Water and Air Piping	1	LS	$7,500.00	$7,500	0	0	$48	$0	$0.00	$0	$7,500	
5	Provide Floor Drains, Both Levels	1	LS	$10,000.00	$10,000	0	0	$48	$0	$0.00	$0	$10,000	
6	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
Subtotal Mechanical in Extended Building					**$70,600**		**124.4**		**$5,971**		**$0**	**$76,571**	**$76,571**

Yard Modifications

1	Demolish Asphalt and Curbs	1	LS	$750.00	$750	0	0	$35	$0	$0.00	$0	$750	
2	Remove Fuel Pumps	1	EA	$800.00	$800	0	0	$35	$0	$0.00	$0	$800	
3	Concrete Island	5	CY	$300.00	$1,500	0	0	$35	$0	$0.00	$0	$1,500	
3a	Drill/Set Dowel Bars	1	LS	$2,000.00	$2,000	0	0	$35	$0	$0.00	$0	$2,000	
3b	Guard Posts	4	EA	$150.00	$600	0	0	$35	$0	$0.00	$0	$600	
3c	Set Fuel Pump	1	EA	$900.00	$900	0	0	$35	$0	$0.00	$0	$900	
3d	Fuel Pump Piping	1	LS	$3,500.00	$3,500	0	0	$35	$0	$0.00	$0	$3,500	
4	Modify Water Piping	1	LS	$3,500.00	$3,500	0	0	$35	$0	$0.00	$0	$3,500	
5	Modify Vent Piping	1	LS	$2,500.00	$2,500	0	0	$35	$0	$0.00	$0	$2,500	
6	Modify Trench Drain	1	LS	$2,500.00	$2,500	0	0	$35	$0	$0.00	$0	$2,500	
7	Relocate Yard Hydrant	1	EA	$1,200.00	$1,200	0	0	$35	$0	$0.00	$0	$1,200	
8	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
Subtotal Yard Modifications					**$19,750**		**0**		**$0**		**$0**	**$19,750**	**$19,750**

Provide Transformer Substation, Structural Allowances, Temporary Sludge Dewatering and Miscellaneous

1	MCC Facility Within Existing Structure	1	LS	$40,000.00	$40,000	0	0	$45	$0	$0.00	$0	$40,000
1a	HVAC in Modified MCC Room Allowance	1	LS	$5,000.00	$5,000	0	0	$45	$0	$0.00	$0	$5,000
2	Structural Allowance	1	LS	$400,000.00	$400,000		0	$40	$0		$0	$400,000
3	Transformer, Misc.	1	LS	$0.00	$0		0	$40	$0		$0	$0

3a	**New Transformers, 2000KVA**	2	EA	$42,000.00	$84,000	80	160	$40	$6,400	$600.00	$1,200	$91,600	Note 4	
3b	Transformer Pad & Enclosure	1	LS	$20,000.00	$20,000	0	0	$40	$0	$0.00	$0	$20,000		
3c	New Swichgear @ Dewatering Bldg Base.	1	UNIT	$25,000.00	$25,000	0	0	$40	$0	$0.00	$0	$25,000		
3d	New Breaker @ Switchgear Bldg.	1	EA	$10,000.00	$10,000	60	60	$40	$2,400	$0.00	$0	$12,400		
4	Elec. Duct Bank, Conduit, Cables	2400	LF	$0.00	$0	0	0	$40	$0	$0.00	$0	$0		
4a	Excavation	1	LS	$0.00	$0	0	0	$40	$0	$6,000.00	$6,000	$6,000		
4b	Concrete	1	LS	$59,000.00	$59,000	0	0	$40	$0	$0.00	$0	$59,000		
4c	4-Inch Conduit	1	LS	$72,000.00	$72,000	0	0	$40	$0	$0.00	$0	$72,000		
4d	Elec. Man Holes	1	LS	$15,000.00	$15,000	0	0	$40	$0	$0.00	$0	$15,000		
4e	Conductors (3 per phase)	21,600	LF	$7.00	$151,200	0.041	885.6	$40	$35,424	$0.00	$0	$186,624		
4f	Conductors, Xfrm to Switchgear	5,000	LF	$6.25	$31,250	0.039	195	$40	$7,800	$0.00	$0	$39,050		
4g	Conductors, Switchgear to Exist. MCC	1,500	LF	$6.25	$9,375	0.039	58.5	$40	$2,340	$0.00	$0	$11,715		
5	Construction Sequence Allowance	1	LS	$75,000.00	$75,000		0	$40	$0	$0.00	$0	$75,000		
6	Struvite Control System Allowance	1	LS	$30,000.00	$30,000	0	0	$40	$0	$0.00	$0	$30,000		
6	New Main Conrtrol PNL/PLC	1	LS	$150,000.00	$150,000	0	0	$40	$0	$0.00	$0	$150,000		
6a	Instrumentation Control Diagrams	1	LS	$125,000.00	$125,000	0	0	$40	$0	$0.00	$0	$125,000		
6	Temp. Sludge Dewatering Equipment	1	LS	$1,400,000.00	$1,400,000		0	$40	$0	$0.00	$0	$1,400,000		
6a	Temp. Elec From New Service	1	LS	$40,000.00	$40,000	0	0	$40	$0	$0.00	$0	$40,000		
7	Yard Modification	1	LS	$3,500.00	$3,500		0	$40	$0		$0	$3,500		
Subtotal Centridry Installation					$2,745,325		1359.1		$54,364		$7,200	$2,806,889		$2,806,889

Base Cost for Centrifuges				$12,155,573
Electrical Cost Allowance	20.00%	Note 5	$10,755,573	$2,151,115
Subtotal Base Cost				$14,306,688
Centridry Contingency	5.00%		$7,084,600	$354,230
Subtotal Base Cost				$14,660,918
Estimator's Contingecy	25.00%	Note 1	$6,867,858	$1,716,965
Subtotal				$16,377,883
Testing/Commissioning	2.00%			$327,558
Subtotal				$16,705,440
Overhead & Profit	15.00%	Note 2	$9,620,840	$1,443,126
Subtotal				$18,148,566
Bonds/Insur./Mobilization	4.00%			$725,943
Subtotal				$18,874,509
Wa State Sales Tax	8.60%			$1,623,208
Subtotal				$20,497,717
Allied Cost	35.00%			$7,174,201
Subtotal				$27,671,918
Deduct Centridry Engineering Cost				-$709,210
Subtotal				$26,962,708
Mid Point of Construction, 2004	9.30%			$2,507,532
TOTAL ESTIMATED CAPITAL COST IN 1999 $				$29,470,239

Note 1---Contingency applied to all elements excluding Centridry equipment costs. Contingency for this equipment applied independently

Note 2---Overhead and profit applied to all elements excluding Centridry. Cost quote received included overhead and profit for Centridry equipment.

Note 3---Equipment cost includes installation of Centridry System.

Note 4---Power requirements to be sized for both temp. operation of sludge dewatering and startup for new centrifuges. This assumes that the existing MCC is available for modification w/belt presses down.
Power would be split for operation of temporary dewatering and startup of one new centrifuge at a time with centridry startup following commissioning of all new centrifuges and shut-down of temporary.

Note 5---Pecentage allowance for electrical excludes cost for temporary sludge dewatering. Electrical cost for temp. sludge dewatering accounted for above.

ALTERNATIVE 2
South Plant

REPLACE 8 BFP'S WITH 3 CENTRIDRY UNITS AND ON SITE COMPOSTING

Prepared By Brown and Caldwell, February 12, 2002

REVISED

Preliminary Cost Estimate

Demolition of Existing Belt Filter Presses

				Material Cost		Labor				Equipment		
Item	Description	Quantity	Unit	Unit Cost	Amount	Labor Hr.	Total Hr.	Rate	Amount	Unit Cost	Amount	Total
1	Remove Roof Hatch	6	EA	$250.00	$1,500	16	96	$48	$4,608	$300.00	$1,800	$7,908
2	**Remove Portion of FA System**	1	LS	$0.00	$0	0	0	$48	$0	$0.00	$0	$0
2a	Remove Hood and Cables	8	EA	$0.00	$0	8	64	$48	$3,072	$50.00	$400	$3,472
2b	Remove 54-Inch FA Pipe	50	LF	$0.00	$0	1	50	$48	$2,400	$0.00	$0	$2,400
2c	Remove 20-Inch FA Pipe	20	LF	$0.00	$0	0.3	6	$48	$288	$0.00	$0	$288
2d	Remove 30-Inch FA Pipe	36	LF	$0.00	$0	0.5	18	$48	$864	$0.00	$0	$864
2e	Remove 24-Inch FA Pipe	24	LF	$0.00	$0	0.35	8.4	$48	$403	$0.00	$0	$403
2f	R3move 24-Inch Elbows	8	EA	$0.00	$0	1	8	$48	$384	$0.00	$0	$384
3	**Remove Belt Filter Presses**	8	EA	$500.00	$4,000	100	800	$48	$38,400	$2,000.00	$16,000	$58,400
3a	Cut Bolts and Patch Surface	192	EA	$3.00	$576	0.35	67.2	$35	$2,352	$0.00	$0	$2,928
3b	Remove Piping Connections	8	EA	$50.00	$400	16	128	$48	$6,144	$75.00	$600	$7,144
3c	Remove Structural Support System	8	EA	$0.00	$0	32	256	$35	$8,960	$250.00	$2,000	$10,960
3d	Remove Bridge Section	4	EA	$0.00	$0	12	48	$35	$1,680	$75.00	$300	$1,980
3e	Remove BS Piping to Floor	350	LF	$0.00	$0	0.16	56	$48	$2,688	$0.25	$88	$2,776
3f	Salvage Flow Elements	8	EA	$25.00	$200	2	16	$48	$768	$0.00	$0	$968
4	**Remove Feed Pump**	8	EA	$50.00	$400	16	128	$48	$6,144	$150.00	$1,200	$7,744
4a	Break Out Concrete Base	8	EA	$0.00	$0	16	128	$35	$4,480	$150.00	$1,200	$5,680
4b	Cut Bolts/Rebar	128	EA	$0.00	$0	0.25	32	$35	$1,120	$0.00	$0	$1,120
4c	Isolate Seal Water Piping	8	EA	$25.00	$200	1	8	$48	$384	$0.00	$0	$584
4d	**Remove Exist. Polymer Pump**	8	EA	$50.00	$400	6	48	$48	$2,304	$75.00	$600	$3,304
5	**Remove Washwater Pump**	8	EA	$50.00	$400	12	96	$48	$4,608	$100.00	$800	$5,808
5a	Break Out Concrete Base	8	EA	$0.00	$0	16	128	$35	$4,480	$150.00	$1,200	$5,680
5b	Remove Piping	8	EA	$0.00	$0	16	128	$48	$6,144	$100.00	$800	$6,944
5c	Isolate Seal Water Piping	8	EA	$25.00	$200	1	8	$48	$384	$0.00	$0	$584
6	Demo Piping	1	LS	$0.00	$0	0	0	$35	$0	$0.00	$0	$0
6a	Cap 4-Inch POL Piping	8	EA	$4.00	$32	0.5	4	$48	$192	$0.00	$0	$224
6b	Remove 6-Inch Filtrate Piping	500	LF	$0.00	$0	0.16	80	$35	$2,800	$0.00	$0	$2,800
6c	Cap Unused Pipe Penetrations	13	EA	$50.00	$650	1	13	$48	$624	$0.50	$7	$1,281
6d	Remove 6-Inch BS Piping	450	LF	$0.00	$0	0.16	72	$35	$2,520	$0.50	$225	$2,745
6e	Remove Portion of 10-Inch BS	64	LF	$0.00	$0	0.16	10.24	$35	$358	$0.50	$32	$390
6f	Remove Drain Piping	8	EA	$0.00	$0	4	32	$35	$1,120	$0.00	$0	$1,120
7	**Remove MCC CB's**	16	EA	$0.00	$0	8	128	$48	$6,144	$0.00	$0	$6,144
7a	Remove Conductors	8	EA	$0.00	$0	40	320	$48	$15,360	$75.00	$600	$15,960
7b	Remove BFP Control Panel	8	EA	$200.00	$1,600	40	320	$48	$15,360	$150.00	$1,200	$18,160
8	**Remove Conveyors**	168	LF	$0.00	$0	0.5	84	$35	$2,940	$1.50	$252	$3,192
8a	Cut Anchor Bolts	85	EA	$0.00	$0	0.05	4.25	$35	$149	$0.00	$0	$149
8b	Epoxy Patch Anchor Bolts	85	EA	$0.50	$43	0.05	4.25	$35	$149	$0.00	$0	$191
9	**Break Out Conc. Filtrate Contain.**	43	CY	$0.00	$0	6	258	$35	$9,030	$25.00	$1,075	$10,105
9a	Sandblast Conc. Surface	2,300	SF	$0.21	$483	0.022	50.6	$35	$1,771	$0.05	$115	$2,369
9b	Restore Floor Surface	2,300	SF	$3.00	$6,900	0	0	$35	$0	$0.00	$0	$6,900
9c	Remove Conc. Curbs	12	CY	$0.00	$0	4	48	$35	$1,680	$25.00	$300	$1,980
9d	Cut Rebar @ Floor	624	EA	$0.00	$0	0.05	31.2	$35	$1,092	$0.00	$0	$1,092

9e	Patch Rebar @ Floor	624	EA	$0.50	$312	0.05	31.2	$35	$1,092	$0.00	$0	$1,404	
9f	Sandblast Conc. Surface	312	SF	$0.21	$66	0.022	6.864	$35	$240	$0.05	$16	$321	
9g	Restore Floor Surface	312	SF	$3.00	$936	0	0	$35	$0	$0.00	$0	$936	
10	**Remove Grinders**	2	EA	$0.00	$0	16	32	$35	$1,120	$100.00	$200	$1,320	
10a	Remove Control Panels	2	EA	$0.00	$0	16	32	$45	$1,440	$50.00	$100	$1,540	
11	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
12	Replace/Seal Roof Hatches	6	EA	$1,500.00	$9,000	16	96	$35	$3,360	$300.00	$1,800	$14,160	
Subtotal Initial Demolition					**$28,297**		**3983.204**		**$171,600**		**$32,909**	**$232,806**	**$232,806**

Install 3 Centridry Units

1	**Construct Concrete Pedistals**	3	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
1a	Drill Holes for Concrete Piers	120	EA	$2.50	$300	0.25	30	$35	$1,050	$0.00	$0	$1,350	
1b	Epoxy Dowel Bars	120	EA	$2.00	$240	0.083	9.96	$35	$349	$0.00	$0	$589	
1c	Concrete Piers	15	CY	$450.00	$6,750	0	0	$35	$0	$20.00	$300	$7,050	
1d	Drill Holes for Walkway Support	250	EA	$2.50	$625	0.25	62.5	$35	$2,188	$0.00	$0	$2,813	
1e	S.S. Anchor Bolts	250	EA	$10.00	$2,500	0.083	20.75	$35	$726	$0.00	$0	$3,226	
1f	Steel Columns	420	LF	$11.20	$4,704	0.0805	33.81	$48	$1,623	$1.45	$609	$6,936	
1g	Weld Beam Connections	300	LF	$0.41	$123	0.1	30	$48	$1,440	$1.03	$309	$1,872	
1h	Horizontal Steel Beams	520	LF	$18.33	$9,532	0.09	46.8	$48	$2,246	$1.56	$811	$12,589	
1i	Post tops 4" X 4" X 1/4"	100	LBS	$1.00	$100	0.3	30	$48	$1,440	$0.00	$0	$1,540	
1j	Weld Cap to Post Top	80	LF	$0.41	$33	0.1	8	$48	$384	$1.03	$82	$499	
1k	Flat Bar X 1/4-Inch	435	LBS	$0.50	$218	0.3	130.5	$48	$6,264	$0.00	$0	$6,482	
1l	Weld Flat Bar to Beams	250	LF	$0.41	$103	0.1	25	$48	$1,200	$1.03	$258	$1,560	
1m	Fiberglass Grating	1,300	SF	$16.60	$21,580	0.04	52	$35	$1,820	$0.00	$0	$23,400	
1n	Hand Rail	450	LF	$26.00	$11,700	0.234	105.3	$35	$3,686	$0.00	$0	$15,386	
1o	Hand Rail Base Plate	50	EA	$15.00	$750	1	50	$35	$1,750	$0.00	$0	$2,500	
1p	Steel Stairs	2	EA	$4,500.00	$9,000	40	80	$35	$2,800	$0.00	$0	$11,800	
1q	Containment Curbs	8	CY	$450.00	$3,600	0	0	$35	$0	$20.00	$160	$3,760	
1r	Splash Slab	25	CY	$300.00	$7,500	0	0	$35	$0	$20.00	$500	$8,000	
1s	Coating	900	SF	$3.50	$3,150	0	0	$35	$0	$0.00	$0	$3,150	
1t	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
2	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
2a	**Install Centridry Centrifuge Sys.**	1	EA	$7,084,600.00	$7,084,600	0	0	$48	$0	$7,500.00	$7,500	$7,092,100	Note 3
2b	**Support Centridry Exhaust Fan**	3	EA	$500.00	$1,500	0	0	$48	$0	$0.00	$0	$1,500	Note 3
2c	**Support Centridry Scrubber**	3	EA	$800.00	$2,400	0	0	$48	$0	$0.00	$0	$2,400	Note 3
2d	**Support Venturi Scrubber**	3	EA	$800.00	$2,400	0	0	$48	$0	$0.00	$0	$2,400	Note 3
2e	**Support Burner Unit**	3	EA	$2,500.00	$7,500	0	0	$48	$0	$0.00	$0	$7,500	Note 3
2f	Roof Penetration for Stack	3	EA	$1,000.00	$3,000	0	0	$48	$0	$0.00	$0	$3,000	
2g	**Support Scrubber Water Pump**	3	EA	$400.00	$1,200	0	0	$48	$0	$0.00	$0	$1,200	Note 3
2h	**Support Circ. Fan**	3	EA	$500.00	$1,500	0	0	$48	$0	$0.00	$0	$1,500	
2i	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
2j	**Cyclone Screw Conveyor (3 EA)**	3	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	Note 3
2k	**No./So. Screw Conveyor (1 EA)**		EA	$157,000.00	$0	90	0	$48	$0	$5.00	$0	$0	
2l	**Truck Load Conveyor (2 EA)**	2	EA	$106,000.00	$212,000	61	122	$48	$5,856	$5.00	$10	$217,866	
2m	Modify Drop Chutes	4	EA	$1,000.00	$4,000	8	32	$48	$1,536	$0.00	$0	$5,536	
2n	New Drop Chuters	2	EA	$7,500.00	$15,000	60	120	$48	$5,760	$0.00	$0	$20,760	
3	**Install Sludge Feed Pump**	3	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	Note 3
3a	Drill Holes for Dowels	54	EA	$2.50	$135	0.25	13.5	$35	$473	$0.00	$0	$608	
3b	Install Dowels	54	EA	$2.50	$135	0.083	4.482	$35	$157	$0.00	$0	$292	
3ba	Equipment Pads	3	EA	$500.00	$1,500	0	0	$35	$0	$0.00	$0	$1,500	
3c	**Provide VFD**	3	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	Note 3
3d	10-Inch Suction Header	70	LF	$37.50	$2,625	0.774	54.18	$48	$2,601	$0.00	$0	$5,226	
3e	**New Grinder**	3	EA	$25,000.00	$75,000	40	120	$48	$5,760	$50.00	$150	$80,910	
3f	10-Inch X 8-Inch Reducers	6	EA	$201.00	$1,206	1.2	7.2	$48	$346	$0.00	$0	$1,552	
3g	8-Inch Piping	60	LF	$25.00	$1,500	0.649	38.94	$48	$1,869	$0.00	$0	$3,369	

3h	8-Inch Elbows	10	EA	$157.00	$1,570	1.143	11.43	$48	$549	$0.00	$0	$2,119	
3i	8-Inch Tees	9	EA	$268.00	$2,412	1.714	15.426	$48	$740	$0.00	$0	$3,152	
3j	8-Inch Plug Valves	12	EA	$1,175.00	$14,100	9.6	115.2	$48	$5,530	$0.00	$0	$19,630	
3k	8-Inch flex Coupling	6	EA	$299.00	$1,794	2.963	17.778	$48	$853	$0.00	$0	$2,647	
3l	8-Inch flanges	28	EA	$117.00	$3,276	1.412	39.536	$48	$1,898	$0.00	$0	$5,174	
3m	8-Inch Bolt and Gasket Sets	28	EA	$16.25	$455	0	0	$48	$0	$0.00	$0	$455	
3n	10-Inch Tees	3	EA	$555.00	$1,665	2	6	$48	$288	$0.00	$0	$1,953	
3o	10-Inch Elbows	2	EA	$286.00	$572	1.333	2.666	$48	$128	$0.00	$0	$700	
3p	**10-Inch Suction Piping**	30	LF	$37.50	$1,125	0.774	23.22	$48	$1,115	$0.00	$0	$2,240	
3q	10-Inch Elbows	3	EA	$286.00	$858	1.333	3.999	$48	$192	$0.00	$0	$1,050	
3r	10-Inch Flex Couplings	3	EA	$400.00	$1,200	3.2	9.6	$48	$461	$0.00	$0	$1,661	
3s	1-Inch Weld-O-Let	3	EA	$8.00	$24	0.8	2.4	$48	$115	$2.50	$8	$147	
3t	1-Inch Nipple	3	EA	$1.00	$3	0.48	1.44	$48	$69	$0.00	$0	$72	
3u	Quick coupling	3	EA	$35.00	$105	0.48	1.44	$48	$69	$0.00	$0	$174	
3v	1-Inch Plug Valve	3	EA	$79.00	$237	0.571	1.713	$48	$82	$0.00	$0	$319	
3w	10-Inch Plug Valves	3	EA	$1,725.00	$5,175	10.909	32.727	$48	$1,571	$0.00	$0	$6,746	
3x	10-Inch Flanges	9	EA	$185.00	$1,665	1.714	15.426	$48	$740	$0.00	$0	$2,405	
3y	10-Inch Bolt and Gasket	9	EA	$33.50	$302	0	0	$48	$0	$0.00	$0	$302	
3z	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
4	**8-Inch Discharge Piping**	250	LF	$25.00	$6,250	0.649	162.25	$48	$7,788	$0.00	$0	$14,038	
4a	8-Inch Tee	12	EA	$268.00	$3,216	1.714	20.568	$48	$987	$0.00	$0	$4,203	
4b	8-Inch Elbows	20	EA	$157.00	$3,140	1.143	22.86	$48	$1,097	$0.00	$0	$4,237	
4c	8-Inch X 6-Inch Reducers	6	EA	$99.00	$594	1.043	6.258	$48	$300	$0.00	$0	$894	
4c	8-Inch Plug Valves	3	EA	$1,175.00	$3,525	9.6	28.8	$48	$1,382	$0.00	$0	$4,907	
4d	6-Inch Plug Valves	8	EA	$655.00	$5,240	8	64	$48	$3,072	$0.00	$0	$8,312	
4e	6-Inch Flow Meter	3	EA	$6,500.00	$19,500	16	48	$48	$2,304	$0.00	$0	$21,804	
4f	8-Inch Flex Couplings	3	EA	$299.00	$897	2.963	8.889	$48	$427	$0.00	$0	$1,324	
4g	1-Inch Weld-O-Let	3	EA	$8.00	$24	0.8	2.4	$48	$115	$2.50	$8	$147	
4h	1-Inch Nipple	3	EA	$1.00	$3	0.48	1.44	$48	$69	$0.00	$0	$72	
4i	1-Inch Plug Valve	3	EA	$79.00	$237	0.571	1.713	$48	$82	$0.00	$0	$319	
4j	1-Inch Quick Coupling	3	EA	$35.00	$105	0.48	1.44	$48	$69	$0.00	$0	$174	
4k	1/2-Inch Thread-O-Let	3	EA	$7.00	$21	0.7	2.1	$48	$101	$2.00	$6	$128	
4l	Chem Seal	3	EA	$450.00	$1,350	1	3	$48	$144	$0.00	$0	$1,494	
4m	Pressure Switch	3	EA	$450.00	$1,350	1	3	$48	$144	$0.00	$0	$1,494	
4n	Pressure Indicator	3	EA	$50.00	$150	0.25	0.75	$48	$36	$0.00	$0	$186	
4o	Seal Water Station	3	EA	$750.00	$2,250	32	96	$48	$4,608	$0.00	$0	$6,858	
4p	**Install Flow Meters**	3	EA	$5,500.00	$16,500	16	48	$48	$2,304	$0.00	$0	$18,804	
4q	8-Inch Flanges	31	EA	$117.00	$3,627	1.412	43.772	$48	$2,101	$0.00	$0	$5,728	
4r	8-Inch Bolt and Gasket Sets	31	EA	$16.25	$504	0	0	$48	$0	$0.00	$0	$504	
5	**Install Centrate Piping-10-Inch**	200	LF	$48.00	$9,600	0.774	154.8	$48	$7,430	$0.00	$0	$17,030	Glass Lined
5a	10-Inch Flex Coupling	3	EA	$400.00	$1,200	3.2	9.6	$48	$461	$0.00	$0	$1,661	
5b	10-Inch Elbows	6	EA	$350.00	$2,100	1.333	7.998	$48	$384	$0.00	$0	$2,484	
5c	10-Inch Plug Valves	3	EA	$1,725.00	$5,175	10.909	32.727	$48	$1,571	$0.00	$0	$6,746	
5d	Connect To Existing	3	EA	$350.00	$1,050	4	12	$48	$576	$0.00	$0	$1,626	
5e	10-Inch Flanges	12	EA	$185.00	$2,220	1.714	20.568	$48	$987	$0.00	$0	$3,207	
5f	10-Inch Bolt and Gasket	12	EA	$33.50	$402	0	0	$48	$0	$0.00	$0	$402	
6	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
7	**3-Inch C3HP Piping**	120	LF	$10.30	$1,236	0.296	35.52	$48	$1,705	$0.00	$0	$2,941	
7a	3-Inch Elbows	10	EA	$14.00	$140	1.455	14.55	$48	$698	$0.00	$0	$838	
7b	3-Inch Tees	6	EA	$26.00	$156	2.286	13.716	$48	$658	$0.00	$0	$814	
7d	3-Inch Ball Valves	4	EA	$95.00	$380	2	8	$48	$384	$0.00	$0	$764	
7e	3-Inch Motorized Valves	3	EA	$633.00	$1,899	4	12	$48	$576	$0.00	$0	$2,475	
7f	1-Inch C3HP Piping	30	LF	$4.00	$120	0.15	4.5	$48	$216	$0.00	$0	$336	
7g	1-Inch Elbows	10	EA	$7.00	$70	0.5	5	$48	$240	$0.00	$0	$310	
7h	1-Inch Flushing Connections	6	EA	$100.00	$600	4	24	$48	$1,152	$0.00	$0	$1,752	
8	**Extend 3-Inch POL Piping**	150	LF	$5.45	$818	0.32	48	$48	$2,304	$0.00	$0	$3,122	
8a	3-Inch Valves	6	EA	$195.00	$1,170	1	6	$48	$288	$0.00	$0	$1,458	
8b	3-Inch Elbows	24	EA	$9.25	$222	1.142	27.408	$48	$1,316	$0.00	$0	$1,538	
8c	3-Inch Tees	12	EA	$17.00	$204	1.778	21.336	$48	$1,024	$0.00	$0	$1,228	
8d	3-Inch Flow Meter	3	EA	$3,500.00	$10,500	3	9	$48	$432	$0.00	$0	$10,932	

8e	3-Inch Motor Oper. Valve	3	EA	$1,200.00	$3,600	5	15	$48	$720	$0.00	$0	$4,320
8f	**Install new Polymer Pump**	3	EA	$5,500.00	$16,500	32	96	$48	$4,608	$75.00	$225	$21,333
8g	Modify Pipe & Calibration	3	LS	$2,500.00	$7,500	60	180	$48	$8,640	$0.00	$0	$16,140
8h	**Install VFD**	3	EA	$4,500.00	$13,500	20	60	$48	$2,880	$0.00	$0	$16,380
9	**Modify FA Piping**	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0
9a	36-Inch FA Piping	100	LF	$82.50	$8,250	1.165	116.5	$48	$5,592	$0.00	$0	$13,842
9b	36-Inch Tees	9	EA	$565.00	$5,085	10.573	95.157	$48	$4,568	$0.00	$0	$9,653
9a	24-Inch FA Piping	40	LF	$56.50	$2,260	0.649	25.96	$48	$1,246	$0.00	$0	$3,506
9b	24-Inch FA Elbow	2	EA	$415.00	$830	4.898	9.796	$48	$470	$0.00	$0	$1,300
9c	24-Inch FA Tee	4	EA	$300.00	$1,200	6.936	27.744	$48	$1,332	$0.00	$0	$2,532
9d	12-Inch FA Piping	120	LF	$24.00	$2,880	0.235	28.2	$48	$1,354	$0.00	$0	$4,234
9e	12-Inch Elbows	16	LF	$133.00	$2,128	2.462	39.392	$48	$1,891	$0.00	$0	$4,019
9f	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0
9h	12-Inch Damper	8	EA	$266.00	$2,128	2.222	17.776	$48	$853	$0.00	$0	$2,981
10	**Extend FA to Trailer Locations**	4	EA	$2,000.00	$8,000	0	0	$48	$0	$0.00	$0	$8,000
11	**Bridge Crane (avg 32' span)**	2	EA	$28,100.00	$56,200	43	86	$48	$4,128	$200.00	$400	$60,728
12	**HVAC Mods to Exist Room**	1	LS	$20,000.00	$20,000	0	0	$48	$0	$0.00	$0	$20,000
13	**Provide 1-Inch HP Sludge Gas**	800	LF	$1.73	$1,384	0.151	120.8	$48	$5,798	$0.00	$0	$7,182
13a	Pressure Reducers	2	EA	$750.00	$1,500	2	4	$48	$192	$0.00	$0	$1,692
13b	Connection @ Plant HP Gas	1	LS	$500.00	$500	0	0	$48	$0	$0.00	$0	$500
14	**Provide 1-Inch Natural Gas**	800	LF	$1.73	$1,384	0.151	120.8	$48	$5,798	$0.00	$0	$7,182
14a	Gas Meter	1	EA	$150.00	$150	1	1	$48	$48	$0.00	$0	$198
14b	Pressure Reducers	2	EA	$750.00	$1,500	2	4	$48	$192	$0.00	$0	$1,692
14c	Connection @ NG Main	1	LS	$1,000.00	$1,000	0	0	$0	$0	$48.00	$48	$1,048
15	**Truck Scale Modifications**	2	EA	$20,000.00	$40,000	0	0	$48	$0	$0.00	$0	$40,000
16	Hot Air Duct Wall Penetration	3	EA	$1,000.00	$3,000	0	0	$35	$0	$0.00	$0	$3,000
17	Misc. Elements @ Centridry	3	EA	$4,000.00	$12,000	100	300	$48	$14,400	$500.00	$1,500	$27,900
Subtotal Centifuges					**$7,856,468**		**3907.011**		**$181,966**		**$12,883**	**$8,051,317**

$8,051,317

Extend Existing Dewatering Building South to Facilitate Centridry Cyclone Unit

31 feet X 58 feet

1	Asphalt Removal	320	SY		$0		0	$35	$0		$0	$0
1a	Site Excavation	380	CY	$0.00	$0	3.75	1425	$35	$49,875	$0.00	$0	$49,875
1b	Material Disposal	380	CY	$0.00	$0	0	0	$35	$0	$8.00	$3,040	$3,040
1c	Structural Fill	170	CY	$12.00	$2,040	0.16	27.2	$35	$952	$1.50	$255	$3,247
1d	Base Rock	42	CY	$15.00	$630	0.16	6.72	$35	$235	$1.50	$63	$928
1e	Vapor Barrier	255	SY	$1.50	$383	0	0	$35	$0	$0.00	$0	$383
2	Slab On Grade @ EL 126	170	CY	$350.00	$59,500	0	0	$35	$0	$20.00	$3,400	$62,900
3	Ground Floor Concrete Walls	61	CY	$400.00	$24,400	0	0	$35	$0	$20.00	$1,220	$25,620
3a	Ground Floor H Columns	72	LF	$44.00	$3,168	0.054	3.888	$40	$156	$1.25	$90	$3,414
3b	H Column Encasement	3	CY	$475.00	$1,425	0	0	$35	$0	$20.00	$60	$1,485
3c	Perimeter Steel Beams	246	LF	$88.00	$21,648	0.108	26.568	$40	$1,063	$1.50	$369	$23,080
3d	Perimeter Beam Encasement	28	CY	$475.00	$13,300	0	0	$35	$0	$20.00	$560	$13,860
3e	Chip Out Existing Columns	3	EA	$1,500.00	$4,500	0	0	$35	$0	$0.00	$0	$4,500
3f	Steel Column Attachment	3	EA	$750.00	$2,250	0	0	$35	$0	$0.00	$0	$2,250
4	Second Floor	66	CY	$450.00	$29,700	0	0	$35	$0	$20.00	$1,320	$31,020
4a	Second Floor H Columns	132	LF	$44.00	$5,808	0.054	7.128	$40	$285	$1.25	$165	$6,258
4b	H Column Encasement	11	CY	$475.00	$5,225	0	0	$35	$0	$20.00	$220	$5,445
4c	Perimeter Steel Beams	246	LF	$44.00	$10,824	0.054	13.284	$40	$531	$1.25	$308	$11,663
4d	Perimeter Beam Encasement	28	CY	$475.00	$13,300	0	0	$35	$0	$20.00	$560	$13,860
5	Roof Slab @ El 150	45	CY	$450.00	$20,250	0	0	$35	$0	$20.00	$900	$21,150
5a	Cants	178	LF	$2.03	$361	0.025	4.45	$35	$156	$0.00	$0	$517
5b	3-Inch Roof Insulation	1,800	SF	$3.12	$5,616	0.011	19.8	$35	$693	$0.00	$0	$6,309
5c	4-Ply Built Up Roofing	1,800	SF	$0.64	$1,152	0.028	50.4	$35	$1,764	$0.16	$288	$3,204
5d	Roof Drains	2	EA	$100.00	$200	1	2	$40	$80	$0.00	$0	$280
5e	Scuppers	2	EA	$50.00	$100	1	2	$35	$70	$0.00	$0	$170

5f	Roof Gravel Cover	1,800	SF	$0.38	$684	0.002	3.6	$35	$126	$0.14	$252	$1,062	
6	Precast Wall Panels	3,000	SF	$11.50	$34,500	0.04	120	$35	$4,200	$1.00	$3,000	$41,700	
6a	Panel Seimic Work	1	LS	$25,000.00	$25,000	0	0	$35	$0	$0.00	$0	$25,000	
7	New Replacement Truck Bay Doors	4	EA	$15,800.00	$63,200	48	192	$35	$6,720	$1,200.00	$4,800	$74,720	
7a	Double Man Door	2	EA	$1,500.00	$3,000	14	28	$35	$980	$0.00	$0	$3,980	
8	Remove Panel At Truck Bay	1	EA	$0.00	$0	32	32	$35	$1,120	$500.00	$500	$1,620	
9	Saw Cut for Two Doors, 2nd Level	2	EA	$300.00	$600	0	0	$35	$0	$0.00	$0	$600	
9a	Man Doors	2	EA	$1,000.00	$2,000	8	16	$35	$560	$0.00	$0	$2,560	
10	**Remove Precast Pnl @ Elev 126**	1,276	SF	$0.00	$0	0.25	319	$35	$11,165	$2.36	$3,011	$14,176	
10a	Saw Cut Curb Wall	58	LF	$3.22	$187	0.805	46.69	$48	$2,241	$24.75	$1,436	$3,863	
10b	Demo Curb Wall	1	CY	$0.00	$0	27	27	$35	$945	$95.00	$95	$1,040	
10c	Bush Surface	58	SF	$0.03	$2	0.074	4.292	$35	$150	$0.27	$16	$168	
10d	Patch Floor Surface @ Old Curb Line	58	SF	$4.00	$232	0	0	$35	$0	$0.00	$0	$232	
10e	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
11	**Acoustical Wall Treatment @ Elev 126**	4,300	SF	$6.00	$25,800	0.052	223.6	$35	$7,826	$0.10	$430	$34,056	
12	**Line Exist Filtrate Sump**	900	SF	$20.00	$18,000	0	0	$35	$0	$0.00	$0	$18,000	
12a	By Pass Pump & Storage Allowance	1	LS	$0.00	$0	0	0	$35	$0	$15,000.00	$15,000	$15,000	
13	Floor Coating	3,600	SF	$3.50	$12,600	0	0	$35	$0	$0.00	$0	$12,600	
14	Coat Interior Concrete Walls	1,800	SF	$0.20	$360	0.015	27	$35	$945	$0.10	$180	$1,485	
15	Equipment & Pipe Coating Allowance	1	LS	$35,000.00	$35,000	0	0	$35	$0	$0.00	$0	$35,000	
16	Scrubber Wall Penetration	2	EA	$500.00	$1,000	16	32	$45	$1,440	$150.00	$300	$2,740	
Subtotal Building Extention					**$447,944**		**2659.62**		**$94,278**		**$41,837**	**$584,059**	**$584,059**

Extend Truck Bay to East for Additional Scales and Extension of Conveyor over Bay 18 fee X 45 feet

1	Site Excavation	265	CY	$0.00	$0	3.75	993.75	$35	$34,781	$0.00	$0	$34,781
1a	Material Disposal	265	CY	$0.00	$0	0	0	$35	$0	$8.00	$2,120	$2,120
1b	Structural Fill	130	CY	$12.00	$1,560	0.16	20.8	$35	$728	$1.50	$195	$2,483
1c	Base Rock	15	CY	$15.00	$225	0.16	2.4	$35	$84	$1.50	$23	$332
1d	Vapor Barrier	100	SY	$1.50	$150	0	0	$35	$0	$0.00	$0	$150
2	Slab On Grade for Truck Scales	40	CY	$350.00	$14,000	0	0	$35	$0	$20.00	$800	$14,800
2a	Extend Center wall section btw bays	18	CY	$400.00	$7,200	0	0	$35	$0	$20.00	$360	$7,560
2b	Extend side wall sections north and south	24	CY	$400.00	$9,600	0	0	$35	$0	$20.00	$480	$10,080
2c	Extend Cant. One side only	16	CY	$400.00	$6,400	0	0	$35	$0	$20.00	$320	$6,720
2d	Extend Slab North of Truck Bays	20	CY	$350.00	$7,000	0	0	$35	$0	$20.00	$400	$7,400
2e	Drill Holes Existing Slab	120	EA	$2.00	$240	0.25	30	$35	$1,050	$0.00	$0	$1,290
2f	Set Dowel Bars Existing Slab	120	EA	$1.50	$180	0.1	12	$35	$420	$0.00	$0	$600
2g	East End Wall	49	CY	$350.00	$17,150	0	0	$35	$0	$20.00	$980	$18,130
3	Ground Floor H Columns (3 ea)	36	LF	$44.00	$1,584	0.054	1.944	$40	$78	$1.25	$45	$1,707
3a	H Column Encasement	3.5	CY	$475.00	$1,663	0	0	$35	$0	$20.00	$70	$1,733
3b	Perimeter Steel Beams W24X55 @ El 126	70	LF	$37.00	$2,590	0.072	5.04	$40	$202	$1.36	$95	$2,887
3c	Perimeter Steel Beams W10 X33 @ El 126	51	LF	$22.00	$1,122	0.102	5.202	$40	$208	$2.58	$132	$1,462
3d	Beam to Column Attachment	10	EA	$150.00	$1,500	2	20	$40	$800	$10.00	$100	$2,400
3e	Perimeter Beam Encasement	16	CY	$475.00	$7,600	0	0	$35	$0	$20.00	$320	$7,920
3f	Chip Out Existing Columns	3	EA	$1,500.00	$4,500	0	0	$35	$0	$0.00	$0	$4,500
3g	Steel Column Attachment	3	EA	$750.00	$2,250	0	0	$35	$0	$0.00	$0	$2,250
3h	Precast Curb Wall @ Perimeter	3	CY	$400.00	$1,200	0	0	$35	$0	$20.00	$60	$1,260
4	2nd Floor Slab @ El 126	30	CY	$450.00	$13,500	0	0	$35	$0	$20.00	$600	$14,100
4a	2nd Floor H Columns (3 ea)	36	LF	$44.00	$1,584	0.054	1.944	$40	$78	$1.25	$45	$1,707
4b	H Column Encasement	3.5	CY	$475.00	$1,663	0	0	$35	$0	$20.00	$70	$1,733
4c	Perimeter Steel Beams W24X55 @ El 126	70	LF	$37.00	$2,590	0.072	5.04	$40	$202	$1.36	$95	$2,887
4d	Perimeter Steel Beams W10 X33 @ El 126	51	LF	$22.00	$1,122	0.102	5.202	$40	$208	$2.58	$132	$1,462
4e	Beam to Column Attachment	10	EA	$150.00	$1,500	2	20	$40	$800	$10.00	$100	$2,400
4f	Perimeter Beam Encasement	16	CY	$475.00	$7,600	0	0	$35	$0	$20.00	$320	$7,920
4g	Chip Out Existing Columns	3	EA	$1,500.00	$4,500	0	0	$35	$0	$0.00	$0	$4,500
4h	Steel Column Attachment	3	EA	$750.00	$2,250	0	0	$35	$0	$0.00	$0	$2,250

4i	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
5	Roof Slab @ El 126	20	CY	$450.00	$9,000	0	0	$35	$0	$20.00	$400	$9,400	
5a	Cants	126	LF	$2.03	$256	0.025	3.15	$35	$110	$0.00	$0	$366	
5b	3-Inch Roof Insulation	810	SF	$3.12	$2,527	0.011	8.91	$35	$312	$0.00	$0	$2,839	
5c	4-Ply Built Up Roofing	810	SF	$0.64	$518	0.028	22.68	$35	$794	$0.16	$130	$1,442	
5d	Roof Drains	2	EA	$100.00	$200	1	2	$40	$80	$0.00	$0	$280	
5e	Scuppers	2	EA	$50.00	$100	1	2	$35	$70	$0.00	$0	$170	
5f	Roof Gravel Cover	810	SF	$0.38	$308	0.002	1.62	$35	$57	$0.14	$113	$478	
6	Precast Wall Panels	1,400	SF	$11.50	$16,100	0.04	56	$35	$1,960	$1.00	$1,400	$19,460	
6a	Panel Seimic Work	1	LS	$8,000.00	$8,000	0	0	$35	$0	$0.00	$0	$8,000	
6b	Double Man Door	1	EA	$1,500.00	$1,500	14	14	$35	$490	$0.00	$0	$1,990	
7	Floor Coating	1,620	SF	$3.50	$5,670	0	0	$35	$0	$0.00	$0	$5,670	
7a	Coat Interior Concrete Walls/Ceiling	1,000	SF	$0.20	$200	0.015	15	$35	$525	$0.10	$100	$825	
8	Expansion Joint Material 1" X 24"	126	SF	$1.40	$176	0.054	6.804	$35	$238	$0.00	$0	$415	
9	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
Subtotal Truck Bay Structural Expansion					$168,578		1255.486		$44,274		$10,004	$222,856	$222,856

Mechanical in Extended Building Section

31 feet X 58 feet

1	**Equipment Pad for Centridry Cyclone**	3	EA	$1,500.00	$4,500	0	0	$35	$0	$0.00	$0	$4,500	Note 3
2	Extend HVAC System (sf basis)	1	LS	$39,000.00	$39,000	0	0	$48	$0	$0.00	$0	$39,000	
3	Extend 36-Inch FA Piping	65	LF	$82.50	$5,363	1.165	75.725	$48	$3,635	$0.00	$0	$8,997	
3a	12-Inch FA Piping	75	LF	$56.50	$4,238	0.649	48.675	$48	$2,336	$0.00	$0	$6,574	
4	Extend Water and Air Piping	1	LS	$7,500.00	$7,500	0	0	$48	$0	$0.00	$0	$7,500	
5	Provide Floor Drains, both floors	1	LS	$10,000.00	$10,000	0	0	$48	$0	$0.00	$0	$10,000	
6	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
Subtotal Mechanical in Extended Building					$70,600		124.4		$5,971		$0	$76,571	$76,571

Relocate Existing Scrubbers to Composting Area and Provide Screen Wall

1	Disassemble Fan Units	2	EA	$0.00	$0	40	80	$48	$3,840	$1,000.00	$2,000	$5,840
1a	Disassemble Drive Units	2	EA	$0.00	$0	32	64	$48	$3,072	$250.00	$500	$3,572
1b	Remove Panel	2	EA	$0.00	$0	16	32	$48	$1,536	$0.00	$0	$1,536
1c	Truck Transfer to New Site	2	EA	$0.00	$0	0	0	$48	$0	$300.00	$600	$600
2	Cut 60-Inch FA Piping	8	EA	$0.00	$0	1.765	14.12	$48	$678	$0.00	$0	$678
2a	Remove 60-Inch FA Joint	7	EA	$0.00	$0	6.15	43.05	$48	$2,066	$0.00	$0	$2,066
3	Cut 48-Inch FA Pipe	4	EA	$0.00	$0	1.412	5.648	$48	$271	$0.00	$0	$271
3a	Remove 48-Inch FA Joint	4	EA	$0.00	$0	4.5	18	$48	$864	$0.00	$0	$864
4	Cut 42-Inch FA Pipe	4	EA	$0.00	$0	1	5.244	$48	$252	$0.00	$0	$252
5	Cap Existing 60-Inch FA	1	EA	$750.00	$750	11	11	$48	$528	$0.00	$0	$1,278
5a	Remove FA Pipe Sections	350	LF	$0.00	$0	0.5	175	$48	$8,400	$0.00	$0	$8,400
5b	Crane Time for FA Removeal	1	LS	$0.00	$0	0	0	$48	$0	$10,000.00	$10,000	$10,000
6	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0
7	Remove Main Panel	1	EA	$250.00	$250	16	16	$48	$768	$0.00	$0	$1,018
7a	Determinate Terminals	1	LS	$0.00	$0	16	16	$48	$768	$0.00	$0	$768
7b	Truck Transfer to New Site	1	EA	$0.00	$0	2	2	$48	$96	$75.00	$75	$171
8	Replacement Control Instruments	1	LS	$50,000.00	$50,000	0	0	$48	$0	$0.00	$0	$50,000
9	Dispose of FA Duct Off Site	1	LS	$0.00	$0	16	16	$48	$768	$750.00	$750	$1,518
10	**Modify Duct to Carbon Ort**	1	LS	$25,000.00	$25,000	0	0	$48	$0	$0.00	$0	$25,000
10a	Remove Ort Tower	2	EA	$0.00	$0	40	80	$48	$3,840	$2,000.00	$4,000	$7,840
10b	Crane Set Up	1	LS	$0.00	$0	0	0	$48	$0	$1,500.00	$1,500	$1,500
10c	Truck Transfer to New Site	2	EA	$0.00	$0	0	0	$48	$0	$150.00	$300	$300

10d	Move Crane Across Site	1	EA	$0.00	$0	8	8	$48	$384	$600.00	$600	$984	
10e	Set Towers on New Base	2	EA	$300.00	$600	40	80	$48	$3,840	$1,000.00	$2,000	$6,440	
10f	Set Blowers On New Base	2	EA	$300.00	$600	16	32	$48	$1,536	$250.00	$500	$2,636	
10g	Set Control Panels	2	EA	$100.00	$200	8	16	$48	$768	$0.00	$0	$968	
11	**Install New FA Pipe @ Ort**	1	LS	$162,000.00	$162,000	0	0	$48	$0	$0.00	$0	$162,000	
12	**FA Pipe In Compost Area**	1	LS	$179,000.00	$179,000	0	0	$48	$0	$0.00	$0	$179,000	
13	Ort Tower Support to Pad Exc.	1	LS	$167,000.00	$167,000	0	0	$48	$0	$0.00	$0	$167,000	
14	Chemical Containment	1	LS	$79,000.00	$79,000	0	0	$48	$0	$0.00	$0	$79,000	
15	Elec. Cable & Conduit	1	LS	$184,000.00	$184,000	0	0	$48	$0	$0.00	$0	$184,000	
16	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
Subtotal Relocate Existing Scrubbers					**$848,400**		**714.062**		**$34,275**		**$22,825**	**$905,500**	**$905,500**

Yard Modifications

1	Demolish Asphalt and Curbs	1	LS	$750.00	$750	0	0	$35	$0	$0.00	$0	$750	
2	Remove Fuel Pumps	1	EA	$800.00	$800	0	0	$35	$0	$0.00	$0	$800	
3	Concrete Island	5	CY	$300.00	$1,500	0	0	$35	$0	$0.00	$0	$1,500	
3a	Drill/Set Dowel Bars	1	LS	$2,000.00	$2,000	0	0	$35	$0	$0.00	$0	$2,000	
3b	Guard Posts	4	EA	$150.00	$600	0	0	$35	$0	$0.00	$0	$600	
3c	Set Fuel Pump	1	EA	$900.00	$900	0	0	$35	$0	$0.00	$0	$900	
3d	Fuel Pump Piping	1	LS	$3,500.00	$3,500	0	0	$35	$0	$0.00	$0	$3,500	
4	Modify Water Piping	1	LS	$3,500.00	$3,500	0	0	$35	$0	$0.00	$0	$3,500	
5	Modify Vent Piping	1	LS	$2,500.00	$2,500	0	0	$35	$0	$0.00	$0	$2,500	
6	Modify Trench Drain	1	LS	$2,500.00	$2,500	0	0	$35	$0	$0.00	$0	$2,500	
7	Relocate Yard Hydrant	1	EA	$1,200.00	$1,200	0	0	$35	$0	$0.00	$0	$1,200	
8	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
Subtotal Yard Modifications					**$19,750**		**0**		**$0**		**$0**	**$19,750**	**$19,750**

Provide Transformer Substation, Structural Allowances, Temporary Sludge Dewatering and Miscellaneous

1	MCC Facility Within Existing Structure	1	LS	$40,000.00	$40,000	0	0	$45	$0	$0.00	$0	$40,000	
1a	HVAC in Modified MCC Room Allowance	1	LS	$5,000.00	$5,000	0	0	$45	$0	$0.00	$0	$5,000	
2	Structural Allowance	1	LS	$400,000.00	$400,000		0	$40	$0		$0	$400,000	
3	Transformer, Misc.	1	LS	$0.00	$0		0	$40	$0		$0	$0	
3a	**New Transformers, 2000KVA**	2	EA	$42,000.00	$84,000	80	160	$40	$6,400	$600.00	$1,200	$91,600	Note 4
3b	Transformer Pad & Enclosure	1	LS	$20,000.00	$20,000	0	0	$40	$0	$0.00	$0	$20,000	
3c	New Swichgear @ Dewatering Bldg Base.	1	UNIT	$25,000.00	$25,000	0	0	$40	$0	$0.00	$0	$25,000	
3d	New Breaker @ Switchgear Bldg.	1	EA	$10,000.00	$10,000	60	60	$40	$2,400	$0.00	$0	$12,400	
4	Elec. Duct Bank, Conduit, Cables	2400	LF	$0.00	$0	0	0	$40	$0	$0.00	$0	$0	
4a	Excavation	1	LS	$0.00	$0	0	0	$40	$0	$6,000.00	$6,000	$6,000	
4b	Concrete	1	LS	$59,000.00	$59,000	0	0	$40	$0	$0.00	$0	$59,000	
4c	4-Inch Conduit	1	LS	$72,000.00	$72,000	0	0	$40	$0	$0.00	$0	$72,000	
4d	Elec. Man Holes	1	LS	$15,000.00	$15,000	0	0	$40	$0	$0.00	$0	$15,000	
4e	Conductors (3 per phase)	21,600	LF	$7.00	$151,200	0.041	885.6	$40	$35,424	$0.00	$0	$186,624	
4f	Conductors, Xfrm to Switchgear	5,000	LF	$6.25	$31,250	0.039	195	$40	$7,800	$0.00	$0	$39,050	
4g	Conductors, Switchgear to Exist. MCC	1,500	LF	$6.25	$9,375	0.039	58.5	$40	$2,340	$0.00	$0	$11,715	
5	Construction Sequence	1	LS	$75,000.00	$75,000		0	$40	$0		$0	$75,000	
	Struvite Control System Allowance	1	LS	$30,000.00	$30,000	0	0	$40	$0	$0.00	$0	$30,000	
6	New Main Control PNL/PLC	1	LS	$150,000.00	$150,000	0	0	$40	$0	$0.00	$0	$150,000	
6a	Instrumentation Control Diagrams	1	LS	$125,000.00	$125,000	0	0	$40	$0	$0.00	$0	$125,000	
7	Temp. Sludge Dewatering Equipment	1	LS	$1,400,000.00	$1,400,000		0	$40	$0	$0.00	$0	$1,400,000	
7a	Temp. Elec From New Service	1	LS	$40,000.00	$40,000	0	0	$40	$0	$0.00	$0	$40,000	

8	Yard Modification	1	LS	$3,500.00	$3,500		0	$40	$0	$0.00	$0	$3,500		
Subtotal Centridry Installation					**$2,745,325**		**1359.1**		**$54,364**		**$7,200**	**$2,806,889**		**$2,806,889**

Base Cost for Centrifuges			**$12,899,748**
Electrical Cost Allowance	20.00% Note 5	$11,499,748	$2,299,950
Subtotal Base Cost			**$15,199,698**
Centridry Contingency	5.00%	$7,084,600	**$354,230**
Subtotal Base Cost			**$15,553,928**
Estimator's Contingecy	25.00% Note 1	$7,760,868	$1,940,217
Subtotal			**$17,494,145**
Compost Facility W/Contingency			$5,024,000
Subtotal			**$22,518,145**
Testing/Commissioning	2.00%		$450,363
Subtotal			**$22,968,508**
Overhead & Profit	15.00% Note 2	$15,529,678	$2,329,452
Subtotal			**$25,297,960**
Bonds/Insur./Mobilization	4.00%		$1,011,918
Subtotal			**$26,309,878**
Wa State Sales Tax	8.60%		$2,262,650
Subtotal			**$28,572,528**
Allied Cost	35.00%		$10,000,385
Subtotal			**$38,572,912**
Deduct Centridry Engineering Cost			-$709,210
Subtotal			**$37,863,702**
Mid Point of Construction, 2004	9.30%		**$3,521,324**
TOTAL ESTIMATED CAPITAL COST IN 1999 $			**$41,385,027**

Note 1---Contingency applied to all elements excluding Centridry equipment costs. Contingency for this equipment applied independently

Note 2---Overhead and profit applied to all elements excluding Centridry. Cost quote received included overhead and profit for Centridry equipment.

Note 3---Equipment cost includes installation of Centridry System.

Note 4---Power requirements to be sized for both temp. operation of sludge dewatering and startup for new centrifuges. This assumes that the existing MCC is available for modification w/belt presses down. Power would be split for operation of temporary dewatering and startup of one new centrifuge at a time with centridry startup following commissioning of all new centrifuges and shut-down of temporary.

Note 5---Pecentage allowance for electrical excludes cost for temporary sludge dewatering. Electrical cost for temp. sludge dewatering accounted for above.

ALTERNATIVE 3
South Plant

REPLACE 8 BFP'S WITH 1 CENTRIDRY AND 2 CENTRIFUGES

Prepared By Brown and Caldwell, February 12, 2002

REVISED

Preliminary Cost Estimate

Demolition of Existing Belt Filter Presses

				Material Cost		Labor				Equipment		
Item	Description	Quantity	Unit	Unit Cost	Amount	Labor Hr.	Total Hr.	Rate	Amount	Unit Cost	Amount	Total
1	Remove Roof Hatch	6	EA	$250.00	$1,500	16	96	$48	$4,608	$300.00	$1,800	$7,908
2	**Remove Portion of FA System**	1	LS	$0.00	$0	0	0	$48	$0	$0.00	$0	$0
2a	Remove Hood and Cables	8	EA	$0.00	$0	8	64	$48	$3,072	$50.00	$400	$3,472
2b	Remove 54-Inch FA Pipe	50	LF	$0.00	$0	1	50	$48	$2,400	$0.00	$0	$2,400
2c	Remove 20-Inch FA Pipe	20	LF	$0.00	$0	0.3	6	$48	$288	$0.00	$0	$288
2d	Remove 30-Inch FA Pipe	36	LF	$0.00	$0	0.5	18	$48	$864	$0.00	$0	$864
2e	Remove 24-Inch FA Pipe	24	LF	$0.00	$0	0.35	8.4	$48	$403	$0.00	$0	$403
2f	R3move 24-Inch Elbows	8	EA	$0.00	$0	1	8	$48	$384	$0.00	$0	$384
3	**Remove Belt Filter Presses**	8	EA	$500.00	$4,000	100	800	$48	$38,400	$2,000.00	$16,000	$58,400
3a	Cut Bolts and Patch Surface	192	EA	$3.00	$576	0.35	67.2	$35	$2,352	$0.00	$0	$2,928
3b	Remove Piping Connections	8	EA	$50.00	$400	16	128	$48	$6,144	$75.00	$600	$7,144
3c	Remove Structural Support System	8	EA	$0.00	$0	32	256	$35	$8,960	$250.00	$2,000	$10,960
3d	Remove Bridge Section	4	EA	$0.00	$0	12	48	$35	$1,680	$75.00	$300	$1,980
3e	Remove BS Piping to Floor	350	LF	$0.00	$0	0.16	56	$48	$2,688	$0.25	$88	$2,776
3f	Salvage Flow Elements	8	EA	$25.00	$200	2	16	$48	$768	$0.00	$0	$968
4	**Remove Feed Pump**	8	EA	$50.00	$400	16	128	$48	$6,144	$150.00	$1,200	$7,744
4a	Break Out Concrete Base	8	EA	$0.00	$0	16	128	$35	$4,480	$150.00	$1,200	$5,680
4b	Cut Bolts/Rebar	128	EA	$0.00	$0	0.25	32	$35	$1,120	$0.00	$0	$1,120
4c	Isolate Seal Water Piping	8	EA	$25.00	$200	1	8	$48	$384	$0.00	$0	$584
4d	**Remove Exist. Polymer Pump**	8	EA	$50.00	$400	6	48	$48	$2,304	$75.00	$600	$3,304
5	**Remove Washwater Pump**	8	EA	$50.00	$400	12	96	$48	$4,608	$100.00	$800	$5,808
5a	Break Out Concrete Base	8	EA	$0.00	$0	16	128	$35	$4,480	$150.00	$1,200	$5,680
5b	Remove Piping	8	EA	$0.00	$0	16	128	$48	$6,144	$100.00	$800	$6,944
5c	Isolate Seal Water Piping	8	EA	$25.00	$200	1	8	$48	$384	$0.00	$0	$584
6	Demo Piping	1	LS	$0.00	$0	0	0	$35	$0	$0.00	$0	$0
6a	Cap 4-Inch POL Piping	8	EA	$4.00	$32	0.5	4	$48	$192	$0.00	$0	$224
6b	Remove 6-Inch Filtrate Piping	500	LF	$0.00	$0	0.16	80	$35	$2,800	$0.00	$0	$2,800
6c	Cap Unused Pipe Penetrations	13	EA	$50.00	$650	1	13	$48	$624	$0.50	$7	$1,281
6d	Remove 6-Inch BS Piping	450	LF	$0.00	$0	0.16	72	$35	$2,520	$0.50	$225	$2,745
6e	Remove Portion of 10-Inch BS	64	LF	$0.00	$0	0.16	10.24	$35	$358	$0.50	$32	$390
6f	Remove Drain Piping	8	EA	$0.00	$0	4	32	$35	$1,120	$0.00	$0	$1,120
7	**Remove MCC CB's**	16	EA	$0.00	$0	8	128	$48	$6,144	$0.00	$0	$6,144
7a	Remove Conductors	8	EA	$0.00	$0	40	320	$48	$15,360	$75.00	$600	$15,960
7b	Remove BFP Control Panel	8	EA	$200.00	$1,600	40	320	$48	$15,360	$150.00	$1,200	$18,160
8	**Remove Conveyors**	168	LF	$0.00	$0	0.5	84	$35	$2,940	$1.50	$252	$3,192
8a	Cut Anchor Bolts	85	EA	$0.00	$0	0.05	4.25	$35	$149	$0.00	$0	$149
8b	Epoxy Patch Anchor Bolts	85	EA	$0.50	$43	0.05	4.25	$35	$149	$0.00	$0	$191
9	**Break Out Conc. Filtrate Contain.**	43	CY	$0.00	$0	6	258	$35	$9,030	$25.00	$1,075	$10,105
9a	Sandblast Conc. Surface	2,300	SF	$0.21	$483	0.022	50.6	$35	$1,771	$0.05	$115	$2,369
9b	Restore Floor Surface	2,300	SF	$3.00	$6,900	0	0	$35	$0	$0.00	$0	$6,900
9c	Remove Conc. Curbs	12	CY	$0.00	$0	4	48	$35	$1,680	$25.00	$300	$1,980
9d	Cut Rebar @ Floor	624	EA	$0.00	$0	0.05	31.2	$35	$1,092	$0.00	$0	$1,092

9e	Patch Rebar @ Floor	624	EA	$0.50	$312	0.05	31.2	$35	$1,092	$0.00	$0	$1,404		
9f	Sandblast Conc. Surface	312	SF	$0.21	$66	0.022	6.864	$35	$240	$0.05	$16	$321		
9g	Restore Floor Surface	312	SF	$3.00	$936	0	0	$35	$0	$0.00	$0	$936		
10	**Remove Grinders**	2	EA	$0.00	$0	16	32	$35	$1,120	$100.00	$200	$1,320		
10a	Remove Control Panels	2	EA	$0.00	$0	16	32	$45	$1,440	$50.00	$100	$1,540		
11	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0		
12	Replace/Seal Roof Hatches	6	EA	$1,500.00	$9,000	16	96	$35	$3,360	$300.00	$1,800	$14,160		
Subtotal Initial Demolition					**$28,297**		**3983.204**		**$171,600**		**$32,909**	**$232,806**		**$232,806**

Install 2 Centrifuges and 1 Centridry													
1	**Construct Concrete Pedistals**	3	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
1a	Drill Holes for Concrete Piers	120	EA	$2.50	$300	0.25	30	$35	$1,050	$0.00	$0	$1,350	
1b	Epoxy Dowel Bars	120	EA	$2.00	$240	0.083	9.96	$35	$349	$0.00	$0	$589	
1c	Concrete Piers	15	CY	$450.00	$6,750	0	0	$35	$0	$20.00	$300	$7,050	
1d	Drill Holes for Walkway Support	250	EA	$2.50	$625	0.25	62.5	$35	$2,188	$0.00	$0	$2,813	
1e	S.S. Anchor Bolts	250	EA	$10.00	$2,500	0.083	20.75	$35	$726	$0.00	$0	$3,226	
1f	Steel Columns	420	LF	$11.20	$4,704	0.0805	33.81	$48	$1,623	$1.45	$609	$6,936	
1g	Weld Beam Connections	300	LF	$0.41	$123	0.1	30	$48	$1,440	$1.03	$309	$1,872	
1h	Horizontal Steel Beams	520	LF	$18.33	$9,532	0.09	46.8	$48	$2,246	$1.56	$811	$12,589	
1i	Post tops 4" X 4" X 1/4"	100	LBS	$1.00	$100	0.3	30	$48	$1,440	$0.00	$0	$1,540	
1j	Weld Cap to Post Top	80	LF	$0.41	$33	0.1	8	$48	$384	$1.03	$82	$499	
1k	Flat Bar X 1/4-Inch	435	LBS	$0.50	$218	0.3	130.5	$48	$6,264	$0.00	$0	$6,482	
1l	Weld Flat Bar to Beams	250	LF	$0.41	$103	0.1	25	$48	$1,200	$1.03	$258	$1,560	
1m	Fiberglass Grating	1,300	SF	$16.60	$21,580	0.04	52	$35	$1,820	$0.00	$0	$23,400	
1n	Hand Rail	450	LF	$26.00	$11,700	0.234	105.3	$35	$3,686	$0.00	$0	$15,386	
1o	Hand Rail Base Plate	50	EA	$15.00	$750	1	50	$35	$1,750	$0.00	$0	$2,500	
1p	Steel Stairs	4	EA	$4,500.00	$18,000	40	160	$35	$5,600	$0.00	$0	$23,600	
1q	Containment Curbs	8	CY	$450.00	$3,600	0	0	$35	$0	$20.00	$160	$3,760	
1r	Splash Slab	25	CY	$300.00	$7,500	0	0	$35	$0	$20.00	$500	$8,000	
1s	Coating	900	SF	$3.50	$3,150	0	0	$35	$0	$0.00	$0	$3,150	
1t	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
2	**Install Centrifuge**	2	EA	$700,000.00	$1,400,000	400	800	$48	$38,400	$1,200.00	$2,400	$1,440,800	Note 3
2a	**Install Centridry Centrifuge Sys.**	1	EA	$2,833,840.00	$2,833,840	0	0	$48	$0	$1,200.00	$1,200	$2,835,040	Note 4
2b	**Support Centridry Exhaust Fan**	1	EA	$500.00	$500	0	0	$48	$0	$0.00	$0	$500	Note 4
2c	**Support Centridry Scrubber**	1	EA	$800.00	$800	0	0	$48	$0	$0.00	$0	$800	Note 4
2d	**Support Venturi Scrubber**	1	EA	$800.00	$800	0	0	$48	$0	$0.00	$0	$800	Note 4
2e	**Support Burner Unit**	1	EA	$2,500.00	$2,500	0	0	$48	$0	$0.00	$0	$2,500	Note 4
2f	Roof Penetration for Stack	1	EA	$1,000.00	$1,000	0	0	$48	$0	$0.00	$0	$1,000	
2g	**Support Scrubber Water Pump**	1	EA	$400.00	$400	0	0	$48	$0	$0.00	$0	$400	Note 4
2h	**Support Circ. Fan**	1	EA	$500.00	$500	0	0	$48	$0	$0.00	$0	$500	
2i	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
2j	**Centrifuge Screw Conveyor (2 EA)**	2	EA	$52,000.00	$104,000	40	80	$48	$3,840	$5.00	$10	$107,850	
2k	**No./So. Screw Conveyor (2 EA)**	2	EA	$62,000.00	$124,000	40	80	$48	$3,840	$5.00	$10	$127,850	
2l	**Truck Load Conveyor (2 EA)**	2	EA	$106,000.00	$212,000	61	122	$48	$5,856	$5.00	$10	$217,866	
2m	Modify Drop Chutes	4	EA	$1,000.00	$4,000	8	32	$48	$1,536	$0.00	$0	$5,536	
2n	New Drop Chuters	2	EA	$7,500.00	$15,000	60	120	$48	$5,760	$0.00	$0	$20,760	
3	**Install Sludge Feed Pump**	2	EA	$42,000.00	$84,000	60	120	$48	$5,760	$100.00	$200	$89,960	
3aa	**Install Centridry Feed Pump**	1	EA	$0.00	$0	0	0	$48	$0	$100.00	$100	$100	Note 4
3a	Drill Holes for Dowels	54	EA	$2.50	$135	0.25	13.5	$35	$473	$0.00	$0	$608	
3b	Install Dowels	54	EA	$2.50	$135	0.083	4.482	$35	$157	$0.00	$0	$292	
3ba	Equipment Pads	3	EA	$500.00	$1,500	0	0	$35	$0	$0.00	$0	$1,500	
3c	**Provide VFD**	2	EA	$15,000.00	$30,000	40	80	$48	$3,840	$100.00	$200	$34,040	
3ca	**Install Centridry Feed P. VFD**	1	EA	$0.00	$0	0	0	$48	$0	$100.00	$100	$100	Note 4
3d	10-Inch Suction Header	70	LF	$37.50	$2,625	0.774	54.18	$48	$2,601	$0.00	$0	$5,226	
3e	**New Grinder**	3	EA	$25,000.00	$75,000	40	120	$48	$5,760	$50.00	$150	$80,910	

3f	10-Inch X 8-Inch Reducers	6	EA	$201.00	$1,206	1.2	7.2	$48	$346	$0.00	$0	$1,552	
3g	8-Inch Piping	60	LF	$25.00	$1,500	0.649	38.94	$48	$1,869	$0.00	$0	$3,369	
3h	8-Inch Elbows	10	EA	$157.00	$1,570	1.143	11.43	$48	$549	$0.00	$0	$2,119	
3i	8-Inch Tees	9	EA	$268.00	$2,412	1.714	15.426	$48	$740	$0.00	$0	$3,152	
3j	8-Inch Plug Valves	12	EA	$1,175.00	$14,100	9.6	115.2	$48	$5,530	$0.00	$0	$19,630	
3k	8-Inch flex Coupling	6	EA	$299.00	$1,794	2.963	17.778	$48	$853	$0.00	$0	$2,647	
3l	8-Inch flanges	28	EA	$117.00	$3,276	1.412	39.536	$48	$1,898	$0.00	$0	$5,174	
3m	8-Inch Bolt and Gasket Sets	28	EA	$16.25	$455	0	0	$48	$0	$0.00	$0	$455	
3n	10-Inch Tees	3	EA	$555.00	$1,665	2	6	$48	$288	$0.00	$0	$1,953	
3o	10-Inch Elbows	2	EA	$286.00	$572	1.333	2.666	$48	$128	$0.00	$0	$700	
3p	**10-Inch Suction Piping**	30	LF	$37.50	$1,125	0.774	23.22	$48	$1,115	$0.00	$0	$2,240	
3q	10-Inch Elbows	3	EA	$286.00	$858	1.333	3.999	$48	$192	$0.00	$0	$1,050	
3r	10-Inch Flex Couplings	3	EA	$400.00	$1,200	3.2	9.6	$48	$461	$0.00	$0	$1,661	
3s	1-Inch Weld-O-Let	3	EA	$8.00	$24	0.8	2.4	$48	$115	$2.50	$8	$147	
3t	1-Inch Nipple	3	EA	$1.00	$3	0.48	1.44	$48	$69	$0.00	$0	$72	
3u	Quick coupling	3	EA	$35.00	$105	0.48	1.44	$48	$69	$0.00	$0	$174	
3v	1-Inch Plug Valve	3	EA	$79.00	$237	0.571	1.713	$48	$82	$0.00	$0	$319	
3w	10-Inch Plug Valves	3	EA	$1,725.00	$5,175	10.909	32.727	$48	$1,571	$0.00	$0	$6,746	
3x	10-Inch Flanges	9	EA	$185.00	$1,665	1.714	15.426	$48	$740	$0.00	$0	$2,405	
3y	10-Inch Bolt and Gasket	9	EA	$33.50	$302	0	0	$48	$0	$0.00	$0	$302	
3z	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
4	**8-Inch Discharge Piping**	250	LF	$25.00	$6,250	0.649	162.25	$48	$7,788	$0.00	$0	$14,038	
4a	8-Inch Tee	12	EA	$268.00	$3,216	1.714	20.568	$48	$987	$0.00	$0	$4,203	
4b	8-Inch Elbows	20	EA	$157.00	$3,140	1.143	22.86	$48	$1,097	$0.00	$0	$4,237	
4c	8-Inch X 6-Inch Reducers	6	EA	$99.00	$594	1.043	6.258	$48	$300	$0.00	$0	$894	
4c	8-Inch Plug Valves	3	EA	$1,175.00	$3,525	9.6	28.8	$48	$1,382	$0.00	$0	$4,907	
4d	6-Inch Plug Valves	8	EA	$655.00	$5,240	8	64	$48	$3,072	$0.00	$0	$8,312	
4e	6-Inch Flow Meter	3	EA	$6,500.00	$19,500	16	48	$48	$2,304	$0.00	$0	$21,804	
4f	8-Inch Flex Couplings	3	EA	$299.00	$897	2.963	8.889	$48	$427	$0.00	$0	$1,324	
4g	1-Inch Weld-O-Let	3	EA	$8.00	$24	0.8	2.4	$48	$115	$2.50	$8	$147	
4h	1-Inch Nipple	3	EA	$1.00	$3	0.48	1.44	$48	$69	$0.00	$0	$72	
4i	1-Inch Plug Valve	3	EA	$79.00	$237	0.571	1.713	$48	$82	$0.00	$0	$319	
4j	1-Inch Quick Coupling	3	EA	$35.00	$105	0.48	1.44	$48	$69	$0.00	$0	$174	
4k	1/2-Inch Thread-O-Let	3	EA	$7.00	$21	0.7	2.1	$48	$101	$2.00	$6	$128	
4l	Chem Seal	3	EA	$450.00	$1,350	1	3	$48	$144	$0.00	$0	$1,494	
4m	Pressure Switch	3	EA	$450.00	$1,350	1	3	$48	$144	$0.00	$0	$1,494	
4n	Pressure Indicator	3	EA	$50.00	$150	0.25	0.75	$48	$36	$0.00	$0	$186	
4o	Seal Water Station	3	EA	$750.00	$2,250	32	96	$48	$4,608	$0.00	$0	$6,858	
4p	**Install Flow Meters**	3	EA	$5,500.00	$16,500	16	48	$48	$2,304	$0.00	$0	$18,804	
4q	8-Inch Flanges	31	EA	$117.00	$3,627	1.412	43.772	$48	$2,101	$0.00	$0	$5,728	
4r	8-Inch Bolt and Gasket Sets	31	EA	$16.25	$504	0	0	$48	$0	$0.00	$0	$504	
5	**Install Centrate Piping-10-Inch**	200	LF	$48.00	$9,600	0.774	154.8	$48	$7,430	$0.00	$0	$17,030	Glass Lined
5a	10-Inch Flex Coupling	3	EA	$400.00	$1,200	3.2	9.6	$48	$461	$0.00	$0	$1,661	
5b	10-Inch Elbows	6	EA	$350.00	$2,100	1.333	7.998	$48	$384	$0.00	$0	$2,484	
5c	10-Inch Plug Valves	3	EA	$1,725.00	$5,175	10.909	32.727	$48	$1,571	$0.00	$0	$6,746	
5d	Connect To Existing	3	EA	$350.00	$1,050	4	12	$48	$576	$0.00	$0	$1,626	
5e	10-Inch Flanges	12	EA	$185.00	$2,220	1.714	20.568	$48	$987	$0.00	$0	$3,207	
5f	10-Inch Bolt and Gasket	12	EA	$33.50	$402	0	0	$48	$0	$0.00	$0	$402	
6	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
7	**3-Inch C3HP Piping**	120	LF	$10.30	$1,236	0.296	35.52	$48	$1,705	$0.00	$0	$2,941	
7a	3-Inch Elbows	10	EA	$14.00	$140	1.455	14.55	$48	$698	$0.00	$0	$838	
7b	3-Inch Tees	6	EA	$26.00	$156	2.286	13.716	$48	$658	$0.00	$0	$814	
7d	3-Inch Ball Valves	4	EA	$95.00	$380	2	8	$48	$384	$0.00	$0	$764	
7e	3-Inch Motorized Valves	3	EA	$633.00	$1,899	4	12	$48	$576	$0.00	$0	$2,475	
7f	1-Inch C3HP Piping	30	LF	$4.00	$120	0.15	4.5	$48	$216	$0.00	$0	$336	
7g	1-Inch Elbows	10	EA	$7.00	$70	0.5	5	$48	$240	$0.00	$0	$310	
7h	1-Inch Flushing Connections	6	EA	$100.00	$600	4	24	$48	$1,152	$0.00	$0	$1,752	
8	**Extend 3-Inch POL Piping**	150	LF	$5.45	$818	0.32	48	$48	$2,304	$0.00	$0	$3,122	
8a	3-Inch Valves	6	EA	$195.00	$1,170	1	6	$48	$288	$0.00	$0	$1,458	
8b	3-Inch Elbows	24	EA	$9.25	$222	1.142	27.408	$48	$1,316	$0.00	$0	$1,538	

8c	3-Inch Tees	12	EA	$17.00	$204	1.778	21.336	$48	$1,024	$0.00	$0	$1,228
8d	3-Inch Flow Meter	3	EA	$3,500.00	$10,500	3	9	$48	$432	$0.00	$0	$10,932
8e	3-Inch Motor Oper. Valve	3	EA	$1,200.00	$3,600	5	15	$48	$720	$0.00	$0	$4,320
8f	**Install new Polymer Pump**	3	EA	$5,500.00	$16,500	32	96	$48	$4,608	$75.00	$225	$21,333
8g	Modify Pipe & Calibration	3	LS	$2,500.00	$7,500	60	180	$48	$8,640	$0.00	$0	$16,140
8h	**Install VFD**	3	EA	$4,500.00	$13,500	20	60	$48	$2,880	$0.00	$0	$16,380
9	**Modify FA Piping**	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0
9a	36-Inch FA Piping	100	LF	$82.50	$8,250	1.165	116.5	$48	$5,592	$0.00	$0	$13,842
9b	36-Inch Tees	9	EA	$565.00	$5,085	10.573	95.157	$48	$4,568	$0.00	$0	$9,653
9a	24-Inch FA Piping	40	LF	$56.50	$2,260	0.649	25.96	$48	$1,246	$0.00	$0	$3,506
9b	24-Inch FA Elbow	2	EA	$415.00	$830	4.898	9.796	$48	$470	$0.00	$0	$1,300
9c	24-Inch FA Tee	4	EA	$300.00	$1,200	6.936	27.744	$48	$1,332	$0.00	$0	$2,532
9d	12-Inch FA Piping	120	LF	$24.00	$2,880	0.235	28.2	$48	$1,354	$0.00	$0	$4,234
9e	12-Inch Elbows	16	LF	$133.00	$2,128	2.462	39.392	$48	$1,891	$0.00	$0	$4,019
9f	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0
9h	12-Inch Damper	8	EA	$266.00	$2,128	2.222	17.776	$48	$853	$0.00	$0	$2,981
11	**Bridge Crane (avg 32' span)**	2	EA	$28,100.00	$56,200	43	86	$48	$4,128	$200.00	$400	$60,728
12	**HVAC Mods to Exist Room**	1	LS	$20,000.00	$20,000	0	0	$48	$0	$0.00	$0	$20,000
13	**Provide 1-Inch HP Sludge Gas**	800	LF	$1.73	$1,384	0.151	120.8	$48	$5,798	$0.00	$0	$7,182
13a	Pressure Reducers	2	EA	$750.00	$1,500	2	4	$48	$192	$0.00	$0	$1,692
13b	Connection @ Plant HP Gas	1	LS	$500.00	$500	0	0	$48	$0	$0.00	$0	$500
14	**Provide 1-Inch Natural Gas**	800	LF	$1.73	$1,384	0.151	120.8	$48	$5,798	$0.00	$0	$7,182
14a	Gas Meter	1	EA	$150.00	$150	1	1	$48	$48	$0.00	$0	$198
14b	Pressure Reducers	2	EA	$750.00	$1,500	2	4	$48	$192	$0.00	$0	$1,692
14c	Connection @ NG Main	1	LS	$1,000.00	$1,000	0	0	$0	$0	$48.00	$48	$1,048
15	**Truck Scale Modifications**	2	EA	$20,000.00	$40,000	0	0	$48	$0	$0.00	$0	$40,000
16	Hot Air Duct Wall Penetration	1	EA	$1,000.00	$1,000	0	0	$35	$0	$0.00	$0	$1,000
17	Misc. Elements @ Centridry	3	EA	$4,000.00	$12,000	100	300	$48	$14,400	$500.00	$1,500	$27,900
Subtotal Centifuges					**$5,333,708**		**5147.011**		**$240,446**		**$9,603**	**$5,583,757**

$5,583,757

Extend Existing Dewatering Building South to Facilitate Centridry Cyclone Unit

31 feet X 75 feet

1	Asphalt Removal	370	SY		$0		0	$35	$0		$0	$0
1a	Site Excavation	410	CY	$0.00	$0	3.75	1537.5	$35	$53,813	$0.00	$0	$53,813
1b	Material Disposal	410	CY	$0.00	$0	0	0	$35	$0	$8.00	$3,280	$3,280
1c	Structural Fill	130	CY	$12.00	$1,560	0.16	20.8	$35	$728	$1.50	$195	$2,483
1d	Base Rock	57	CY	$15.00	$855	0.16	9.12	$35	$319	$1.50	$86	$1,260
1e	Vapor Barrier	285	SY	$1.50	$428	0	0	$35	$0	$0.00	$0	$428
2	Slab On Grade @ EL 111	175	CY	$350.00	$61,250	0	0	$35	$0	$20.00	$3,500	$64,750
3	Ground Floor Concrete Walls	70	CY	$400.00	$28,000	0	0	$35	$0	$20.00	$1,400	$29,400
3a	Ground Floor H Columns	80	LF	$44.00	$3,520	0.054	4.32	$40	$173	$1.25	$100	$3,793
3b	H Column Encasement	3.5	CY	$475.00	$1,663	0	0	$35	$0	$20.00	$70	$1,733
3c	Perimeter Steel Beams	300	LF	$88.00	$26,400	0.108	32.4	$40	$1,296	$1.50	$450	$28,146
3d	Perimeter Beam Encasement	34	CY	$475.00	$16,150	0	0	$35	$0	$20.00	$680	$16,830
3e	Chip Out Existing Columns	3	EA	$1,500.00	$4,500	0	0	$35	$0	$0.00	$0	$4,500
3f	Steel Column Attachment	3	EA	$750.00	$2,250	0	0	$35	$0	$0.00	$0	$2,250
4	Second Floor @ El 126	86	CY	$450.00	$38,700	0	0	$35	$0	$20.00	$1,720	$40,420
4a	Second Floor H Columns	176	LF	$44.00	$7,744	0.054	9.504	$40	$380	$1.25	$220	$8,344
4b	H Column Encasement	20	CY	$475.00	$9,500	0	0	$35	$0	$20.00	$400	$9,900
4c	Perimeter Steel Beams	317	LF	$44.00	$13,948	0.054	17.118	$40	$685	$1.25	$396	$15,029
4d	Perimeter Beam Encasement	35	CY	$475.00	$16,625	0	0	$35	$0	$20.00	$700	$17,325
5	Roof Slab @ El 150	58	CY	$450.00	$26,100	0	0	$35	$0	$20.00	$1,160	$27,260
5a	Cants	212	LF	$2.03	$430	0.025	5.3	$35	$186	$0.00	$0	$616
5b	3-Inch Roof Insulation	2,325	SF	$3.12	$7,254	0.011	25.575	$35	$895	$0.00	$0	$8,149
5c	4-Ply Built Up Roofing	2,325	SF	$0.64	$1,488	0.028	65.1	$35	$2,279	$0.16	$372	$4,139
5d	Roof Drains	2	EA	$100.00	$200	1	2	$40	$80	$0.00	$0	$280

5e	Scuppers	2	EA	$50.00	$100	1	2	$35	$70	$0.00	$0	$170
5f	Roof Gravel Cover	2,325	SF	$0.38	$884	0.002	4.65	$35	$163	$0.14	$326	$1,372
6	Precast Wall Panels	3,425	SF	$11.50	$39,388	0.04	137	$35	$4,795	$1.00	$3,425	$47,608
7	Panel Seimic Work	1	LS	$25,000.00	$25,000	0	0	$35	$0	$0.00	$0	$25,000
8	New Replacement Truck Bay Doors	4	EA	$15,800.00	$63,200	48	192	$35	$6,720	$1,200.00	$4,800	$74,720
8a	Double Man Door	2	EA	$1,500.00	$3,000	14	28	$35	$980	$0.00	$0	$3,980
8b	Remove Panel At Truck Bay	1	EA	$0.00	$0	32	32	$35	$1,120	$500.00	$500	$1,620
9	Saw Cut for Two Doors, 2nd Level	2	EA	$300.00	$600	0	0	$35	$0	$0.00	$0	$600
9a	Man Doors	2	EA	$1,000.00	$2,000	8	16	$35	$560	$0.00	$0	$2,560
10	**Remove Precast Pnl @ Elev 126**	1,276	SF	$0.00	$0	0.25	319	$35	$11,165	$2.36	$3,011	$14,176
10a	Saw Cut Curb Wall	58	LF	$3.22	$187	0.805	46.69	$48	$2,241	$24.75	$1,436	$3,863
10b	Demo Curb Wall	1	CY	$0.00	$0	27	27	$35	$945	$95.00	$95	$1,040
10c	Bush Surface	58	SF	$0.03	$2	0.074	4.292	$35	$150	$0.27	$16	$168
10d	Patch Floor Surface @ Old Curb Line	58	SF	$4.00	$232	0	0	$35	$0	$0.00	$0	$232
10e	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0
11	**Acoustical Wall Treatment @ Elev 126**	4,300	SF	$6.00	$25,800	0.052	223.6	$35	$7,826	$0.10	$430	$34,056
12	**Line Exist Filtrate Sump**	900	SF	$20.00	$18,000	0	0	$35	$0	$0.00	$0	$18,000
12a	By Pass Pump & Storage Allowance	1	LS	$0.00	$0	0	0	$35	$0	$15,000.00	$15,000	$15,000
13	Floor Coating	4,650	SF	$3.50	$16,275	0	0	$35	$0	$0.00	$0	$16,275
14	Coat Interior Concrete Walls	1,900	SF	$0.20	$380	0.015	28.5	$35	$998	$0.10	$190	$1,568
15	Scrubber Wall Penetration	2	EA	$500.00	$1,000	16	32	$45	$1,440	$150.00	$300	$2,740
Subtotal Building Extention					$464,611		2821.469		$100,005		$44,257	$608,873

$608,873

Extend Truck Bay to East for Additional Scales and Extension of Conveyor over Bay

18 fee X 45 feet

1	Site Excavation	265	CY	$0.00	$0	3.75	993.75	$35	$34,781	$0.00	$0	$34,781
1a	Material Disposal	265	CY	$0.00	$0	0	0	$35	$0	$8.00	$2,120	$2,120
1b	Structural Fill	130	CY	$12.00	$1,560	0.16	20.8	$35	$728	$1.50	$195	$2,483
1c	Base Rock	15	CY	$15.00	$225	0.16	2.4	$35	$84	$1.50	$23	$332
1d	Vapor Barrier	100	SY	$1.50	$150	0	0	$35	$0	$0.00	$0	$150
2	Slab On Grade for Truck Scales	40	CY	$350.00	$14,000	0	0	$35	$0	$20.00	$800	$14,800
2a	Extend Center wall section btw bays	18	CY	$400.00	$7,200	0	0	$35	$0	$20.00	$360	$7,560
2b	Extend side wall sections north and south	24	CY	$400.00	$9,600	0	0	$35	$0	$20.00	$480	$10,080
2c	Extend Cant. One side only	16	CY	$400.00	$6,400	0	0	$35	$0	$20.00	$320	$6,720
2d	Extend Slab North of Truck Bays	20	CY	$350.00	$7,000	0	0	$35	$0	$20.00	$400	$7,400
2e	Drill Holes Existing Slab	120	EA	$2.00	$240	0.25	30	$35	$1,050	$0.00	$0	$1,290
2f	Set Dowel Bars Existing Slab	120	EA	$1.50	$180	0.1	12	$35	$420	$0.00	$0	$600
2g	East End Wall	49	CY	$350.00	$17,150	0	0	$35	$0	$20.00	$980	$18,130
3	Ground Floor H Columns (3 ea)	36	LF	$44.00	$1,584	0.054	1.944	$40	$78	$1.25	$45	$1,707
3a	H Column Encasement	3.5	CY	$475.00	$1,663	0	0	$35	$0	$20.00	$70	$1,733
3b	Perimeter Steel Beams W24X55 @ El 126	70	LF	$37.00	$2,590	0.072	5.04	$40	$202	$1.36	$95	$2,887
3c	Perimeter Steel Beams W10 X33 @ El 126	51	LF	$22.00	$1,122	0.102	5.202	$40	$208	$2.58	$132	$1,462
3d	Beam to Column Attachment	10	EA	$150.00	$1,500	2	20	$40	$800	$10.00	$100	$2,400
3e	Perimeter Beam Encasement	16	CY	$475.00	$7,600	0	0	$35	$0	$20.00	$320	$7,920
3f	Chip Out Existing Columns	3	EA	$1,500.00	$4,500	0	0	$35	$0	$0.00	$0	$4,500
3g	Steel Column Attachment	3	EA	$750.00	$2,250	0	0	$35	$0	$0.00	$0	$2,250
3h	Precast Curb Wall @ Perimeter	3	CY	$400.00	$1,200	0	0	$35	$0	$20.00	$60	$1,260
4	2nd Floor Slab @ El 126	30	CY	$450.00	$13,500	0	0	$35	$0	$20.00	$600	$14,100
4a	2nd Floor H Columns (3 ea)	36	LF	$44.00	$1,584	0.054	1.944	$40	$78	$1.25	$45	$1,707
4b	H Column Encasement	3.5	CY	$475.00	$1,663	0	0	$35	$0	$20.00	$70	$1,733
4c	Perimeter Steel Beams W24X55 @ El 126	70	LF	$37.00	$2,590	0.072	5.04	$40	$202	$1.36	$95	$2,887
4d	Perimeter Steel Beams W10 X33 @ El 126	51	LF	$22.00	$1,122	0.102	5.202	$40	$208	$2.58	$132	$1,462
4e	Beam to Column Attachment	10	EA	$150.00	$1,500	2	20	$40	$800	$10.00	$100	$2,400
4f	Perimeter Beam Encasement	16	CY	$475.00	$7,600	0	0	$35	$0	$20.00	$320	$7,920
4g	Chip Out Existing Columns	3	EA	$1,500.00	$4,500	0	0	$35	$0	$0.00	$0	$4,500
4h	Steel Column Attachment	3	EA	$750.00	$2,250	0	0	$35	$0	$0.00	$0	$2,250

4i	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
5	Roof Slab @ El 126	20	CY	$450.00	$9,000	0	0	$35	$0	$20.00	$400	$9,400	
5a	Cants	126	LF	$2.03	$256	0.025	3.15	$35	$110	$0.00	$0	$366	
5b	3-Inch Roof Insulation	810	SF	$3.12	$2,527	0.011	8.91	$35	$312	$0.00	$0	$2,839	
5c	4-Ply Built Up Roofing	810	SF	$0.64	$518	0.028	22.68	$35	$794	$0.16	$130	$1,442	
5d	Roof Drains	2	EA	$100.00	$200	1	2	$40	$80	$0.00	$0	$280	
5e	Scuppers	2	EA	$50.00	$100	1	2	$35	$70	$0.00	$0	$170	
5f	Roof Gravel Cover	810	SF	$0.38	$308	0.002	1.62	$35	$57	$0.14	$113	$478	
6	Precast Wall Panels	1,400	SF	$11.50	$16,100	0.04	56	$35	$1,960	$1.00	$1,400	$19,460	
6a	Panel Seimic Work	1	LS	$8,000.00	$8,000	0	0	$35	$0	$0.00	$0	$8,000	
6b	Double Man Door	1	EA	$1,500.00	$1,500	14	14	$35	$490	$0.00	$0	$1,990	
7	Floor Coating	1,620	SF	$3.50	$5,670	0	0	$35	$0	$0.00	$0	$5,670	
7a	Coat Interior Concrete Walls/Ceiling	1,000	SF	$0.20	$200	0.015	15	$35	$525	$0.10	$100	$825	
8	Expansion Joint Material 1" X 24"	126	SF	$1.40	$176	0.054	6.804	$35	$238	$0.00	$0	$415	
9	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
Subtotal Truck Bay Structural Expansion					**$168,578**		**1255.486**		**$44,274**		**$10,004**	**$222,856**	**$222,856**

Mechanical In Extended Building Section

31 feet X 75 feet

1	**Pad for Centridry Cyclone**	1	EA	$1,500.00	$1,500	0	0	$35	$0	$0.00	$0	$1,500	Note 4
2	Extend HVAC System (sf basis)	1	LS	$50,000.00	$50,000	0	0	$48	$0	$0.00	$0	$50,000	
3	Extend 36-Inch FA Piping	65	LF	$82.50	$5,363	1.165	75.725	$48	$3,635	$0.00	$0	$8,997	
3a	12-Inch FA Piping	75	LF	$56.50	$4,238	0.649	48.675	$48	$2,336	$0.00	$0	$6,574	
4	Extend Water and Air Piping	1	LS	$7,500.00	$7,500	0	0	$48	$0	$0.00	$0	$7,500	
5	Provide Floor Drains Both Floors	1	LS	$10,000.00	$10,000	0	0	$48	$0	$0.00	$0	$10,000	
6	**Cyclone Screw Conveyor**	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	Note 4
7	Not Used	1	EA	$0.00	$0	0	0	$48	$0	$0.00	$0	$0	
Subtotal Mechanical In Extended Building					**$78,600**		**124.4**		**$5,971**		**$0**	**$84,571**	**$84,571**

Yard Modifications

1	Demolish Asphalt and Curbs	1	LS	$750.00	$750	0	0	$35	$0	$0.00	$0	$750	
2	Remove Fuel Pumps	1	EA	$800.00	$800	0	0	$35	$0	$0.00	$0	$800	
3	Concrete Island	5	CY	$300.00	$1,500	0	0	$35	$0	$0.00	$0	$1,500	
3a	Drill/Set Dowel Bars	1	LS	$2,000.00	$2,000	0	0	$35	$0	$0.00	$0	$2,000	
3b	Guard Posts	4	EA	$150.00	$600	0	0	$35	$0	$0.00	$0	$600	
3c	Set Fuel Pump	1	EA	$900.00	$900	0	0	$35	$0	$0.00	$0	$900	
3d	Fuel Pump Piping	1	LS	$3,500.00	$3,500	0	0	$35	$0	$0.00	$0	$3,500	
4	Modify Water Piping	1	LS	$3,500.00	$3,500	0	0	$35	$0	$0.00	$0	$3,500	
5	Modify Vent Piping	1	LS	$2,500.00	$2,500	0	0	$35	$0	$0.00	$0	$2,500	
6	Modify Trench Drain	1	LS	$2,500.00	$2,500	0	0	$35	$0	$0.00	$0	$2,500	
7	Relocate Yard Hydrant	1	EA	$1,200.00	$1,200	0	0	$35	$0	$0.00	$0	$1,200	
8	Not Used	1	EA	$0.00	$0	0	0	$35	$0	$0.00	$0	$0	
Subtotal Yard Modifications					**$19,750**		**0**		**$0**		**$0**	**$19,750**	**$19,750**

Provide Transformer Substation, Structural Allowances and Temporary Sludge Dewatering

1	MCC Facility Within Existing Structure	1	LS	$40,000.00	$40,000	0	0	$45	$0	$0.00	$0	$40,000		
1a	HVAC in Modified MCC Room Allowance	1	LS	$5,000.00	$5,000	0	0	$45	$0	$0.00	$0	$5,000		
2	Structural Allowance	1	LS	$400,000.00	$400,000		0	$40	$0	$0.00	$0	$400,000		
3	Transformer, Misc.	1	LS	$0.00	$0		0	$40	$0	$0.00	$0	$0		
3a	Remove Exist Transformer	0	EA	$0.00	$0	76	0	$40	$0	$550.00	$0	$0		
3b	**New Transformers, 2000KVA**	2	EA	$42,000.00	$84,000	80	160	$40	$6,400	$600.00	$1,200	$91,600	Note 5	
3c	Transformer Pad & Enclosure	1	LS	$20,000.00	$20,000	0	0	$40	$0	$0.00	$0	$20,000		
3d	New Swichgear @ Dewater Bsmt.	1	UNIT	$25,000.00	$25,000	0	0	$40	$0	$0.00	$0	$25,000		
3e	New Conductor, Solids Bldg to Xfmr.	5,000	LF	$6.25	$31,250	0.039	195	$40	$7,800	$0.00	$0	$39,050		
3f	New Conductor Xfrm to SwGear/MCC	4,000	LF	$6.25	$25,000	0.039	156	$40	$6,240	$0.00	$0	$31,240		
3g	Transformer Pad & Enclosure	1	LS	$20,000.00	$20,000	0	0	$40	$0	$0.00	$0	$20,000		
4	New Main Control Pnl/PLC	1	EA	$150,000.00	$150,000	0	0	$40	$0	$0.00	$0	$150,000		
4a	Instrumentation Control Diagrams	1	LS	$125,000.00	$125,000	0	0	$40	$0	$0.00	$0	$125,000		
5	Construction Sequence Allowance	1	LS	$75,000.00	$75,000		0	$40	$0	$0.00	$0	$75,000		
6	Struvite Control System Allowance	1	LS	$30,000.00	$30,000	0	0	$40	$0	$0.00	$0	$30,000		
7	Yard Modification	1	LS	$3,500.00	$3,500		0	$40	$0		$0	$3,500		
Subtotal Centridry Installation					**$1,033,750**		**511**		**$20,440**		**$1,200**	**$1,055,390**		**$1,055,390**

Base Cost for Centrifuges				**$7,808,003**
Electrical Cost Allowance	20.00%		$7,808,003	**$1,561,601**
Subtotal Base Cost				**$9,369,603**
Centrifuge Equip. Contingency	5.00%		$4,233,840	$211,692
Subtotal				**$9,581,295**
Estimator's Contingecy	25.00%	Note 1	$5,135,763	$1,283,941
Subtotal				**$10,865,236**
Testing/Commissioning	2.00%			$217,305
Subtotal				**$11,082,541**
Overhead & Profit	15.00%	Note 2	$8,037,009	$1,205,551
Subtotal				**$12,288,092**
Bonds/Insur./Mobilization	4.00%			$491,524
Subtotal				**$12,779,616**
Wa State Sales Tax	8.60%			$1,099,047
Subtotal				**$13,878,663**
Allied Cost	35.00%			$4,857,532
Subtotal				**$18,736,195**
Deduct Centridry Engineering Cost				-$283,000
Subtotal				**$18,453,195**
Mid Point of Construction, 2004	9.30%			**$1,716,147**
TOTAL ESTIMATED CAPITAL				**$20,169,342**

Note 1---Contingency applied to all elements excluding Centridry and centifuge equipment costs. Contingency for this equipment applied independently

Note 2---Overhead and profit applied to all elements excluding Centridry. Cost quote received included overhead and profit for Centridry equipment.

Note 3---Two centrifuge units provided by other than Centridry. Centrifuge cost based on Alph-Laral bid price for 1 DS706 in Oregon, June, 20001.

Note 4---Equipment and installation included in Centridry costs. Costs for 1 Centridry system assumed to be 40% of cost of 3 Centridry systems, as shown in Alt. 1 and 2.

Note 5---Power requirements to be sized for both temp. operation of sludge dewatering and startup for new centrifuges. This assumes that the existing MCC is available for modification w/belt presses down. Power would be split for operation of temporary dewatering and startup of one new centrifuge at a time with centridry startup following commissioning of all new centrifuges.

TAB

I

APPENDIX I

LIFE-CYCLE COST EVALUATION: ALTERNATIVES 0, 1, 2, AND 3

COST MODEL

COMMON TO ALL DEWATERING ALTERNATIVES

Table 1.1
Assumptions Common to all Alternatives Considered in South Plant Centridry Evaluatior

			Info Source
Planning Period	yr	2019	
Planning Year	yr	2009	
Influent Waste Water Flow	mgd	104	1
Peaking Factors (weight) thickened sludge			
Annual Average		1	2
Peak 3-week, applied to avg winter		1.14	2
Max Week, applied to avg winter		1.24	2
Peak Day, applied to avg winter		1.52	2
Peaking Factors (weight) dewatering sludge			
Annual Average		1	2
Peak 3-week, applied to avg winter		1.31	2
Max Week, applied to avg winter		1.43	2
Peak Day, applied to avg winter		1.63	2
Solids Concentration			
Primary Sludge	percent solids	0.6%	4
Waste Activated Sludge	percent solids	0.5%	4
Thickened Sludge	percent solids	5.5%	4
Volatile Solids Ratio			
Primary Sludge	percent of tss	80%	5
Waste Activated Sludge	percent of tss	76%	5
Thickened Sludge	percent of tss	79%	5
Summer Sludge Temperature	F	71	6
Winter Sludge Temperature	F	57	6
Thermophilic Operating Temperature	F	135	6
Mesophilic Operating Temperature	F	95	6
Digester Cone Volume Percent Active	percent	75%	7
Digester Gas Production	(cf/lb vs dest)	15	8

Table 1.2
Projected Solids Process Flows and Loads - 2010

Raw Solids	Flow gpm	Flow gpd	TSS lbs/day	VSS lbs/day	Info Source
Primary Sludge					
Average Annual	1,359	1,957,534	97,955	78,364	23
Peak 3-Week	1,550	2,231,589	111,669	89,335	
Max Week	1,686	2,427,342	121,464	97,171	
Peak Day	2,066	2,975,452	148,892	119,113	
Waste Activated Sludge					
Average Annual	1,436	2,067,818	86,228	65,533	
Peak 3-Week	1,637	2,357,312	98,300	74,708	
Max Week	1,781	2,564,094	106,923	81,261	
Peak Day	2,183	3,143,083	131,067	99,611	

Thickening			Info Source
DAFTS			
Number of Units	no.	4	9

Diameter	ft	55	9			
Number of Units	no.	2	9			
Diameter	ft	65	9			
Total Surface Area	sft	16,140				
Solids Loading, All DAFT's in service						
Average Annual	lb/sf/day	12.0	21			
Peak 3-Week	lb/sf/day	13.7				
Max Week	lb/sf/day	14.9				
Peak Day	lb/sf/day	18.2				
Solids Loading, one 65' diameter DAFT out of service						
Average Annual	lb/sf/day	15.1				
Peak 3-Week	lb/sf/day	17.2				
Max Week	lb/sf/day	18.7				
Peak Day	lb/sf/day	23.0				
Thickened Solids		Flow	Flow	TSS	VSS	
Thickened Sludge		gpm	gpd	lbs/day	lbs/day	Info Source
Average Annual		280	402,752	184,742	145,946	22
Peak 3-Week		366	527,605	242,012	191,190	
Max Week		400	575,935	264,182	208,703	
Peak Day		456	656,486	301,130	237,893	
Thickened Sludge Blending Tank			Info Source			
Number of Units	no.	1	10			
Diameter	ft	8	10			
Sidewater Depth	ft	15	10			
Tank Volume	gallons	5,640				
Total Volume	gallons	5,640				
Detention Time						
Average Annual	minutes	20.2				
Peak 3-Week	minutes	15.4				
Max Week	minutes	14.1				
Peak Day	minutes	12.4				

ALTERNATIVE 0 - REPLACE BELT FILTER PRESSES WITH CENTRIFUGES

Table 2.1
Alternative 0 Assumptions

			Info Source
Volatile Solids Reduction in Digesters	percent	61.0%	11
Dewatering Solids Capture	percent	95.0%	12
Dewatered Cake Solids	percent solids	26.5%	13
Number of Centrifuges		3	

Table 2.2
Alternative 0 Flows and Loads

			Info Source
Anaerobic Mesophillic Digesters			
Existing			
Number of Units (existing)	no.	4	
Diameter	ft	100	14
Sidewater Depth	ft	41.0	14
Tank Cylindrical Volume	gallons	2,408,659	
Tank Cone Volume	gallons	234,088	14
Effective Tank Volume (includes 75% of cone)	gallons	2,584,225	
Total Existing Volume	gallons	10,336,900	
Total Volume	gallons	10,336,900	
Detention Time			
All Digesters in Service			
Average Annual	days	25.7	
Peak 3-Week	days	19.6	
Max Week	days	17.9	
Peak Day	days	15.7	
One Digester Out of Service			
Average Annual	days	19.2	
Peak 3-Week	days	14.7	
Max Week	days	13.5	
Peak Day	days	11.8	
Volatile Solids Loading			
All Digesters in Service			
Average Annual	lbs-vs/cf/day	0.11	
Peak 3-Week	lbs-vs/cf/day	0.14	
Max Week	lbs-vs/cf/day	0.15	
Peak Day	lbs-vs/cf/day	0.17	
One Digester Out of Service			
Average Annual	lbs-vs/cf/day	0.13	
Peak 3-Week	lbs-vs/cf/day	0.17	
Max Week	lbs-vs/cf/day	0.19	
Peak Day	lbs-vs/cf/day	0.22	
Heat Demand			
Digester Heat Loss to Control Bldg	BTUH	189,525	15
Digester Heat Loss from Shell	BTUH	290,099	15
Average Annual	BTUH	6,664,009	
Peak 3-Week	BTUH	8,311,377	
Max Week	BTUH	8,949,068	
Peak Day	BTUH	10,011,885	
Digester Gas Production			
Average Annual	cf/day	1,335,410	
Peak 3-Week	cf/day	1,749,387	
Max Week	cf/day	1,909,636	
Peak Day	cf/day	2,176,718	

	Flow gpm	Flow gpd	TSS lbs/day	VSS lbs/day
Digested Solids				
Digested Sludge				
Average Annual	280	402,752	95,715	56,919
Peak 3-Week	366	527,605	125,387	74,564
Max Week	400	575,935	136,872	81,394
Peak Day	456	656,486	156,015	92,778

			Info Source
Digested Sludge Storage			
Blending Storage Tank			
Diameter	ft	100	16
Sidewater Depth	ft	36.75	16
Tank Cylindrical Volume	gallons	2,158,981	
Tank Cone Volume	gallons	Not Included	

Effective Tank Volume (includes 0% of cone)	gallons	2,158,981				
Total BST Volume	gallons	2,158,981				
Maximum Storage Capacity						
Average Annual	days	5.4				
Peak 3-Week	days	4.1				
Max Week	days	3.7				
Peak Day	days	3.3				
Dewatering		Flow	TSS	VSS	Concentration	
Loading		gpm	lbs/day	lbs/day	% solids	
Average Annual		280	95,715	56,919	2.85%	
Max 3-Week		366	125,387	74,564	2.85%	
Max Week		400	136,872	81,394	2.85%	
Peak Day		456	156,015	92,778	2.85%	
Centrifuge Dewatering						
Number of Units Needed (Units at Peak Day)	no.	3.0				
Nominal Size (Humboldt-Baker)	model	CP3074	Info Source			
Nominal Dewatering Capacity/Centrifuge	dry lbs/hr	2,500	17			
Operating Units at Annual Average Condition	no.	1.6				
Operating Units at Max 3-week Condition	no.	2.1				
Operating Units at Max Week Condition	no.	2.3				
Operating Units at Peak Day Condition	no.	2.6				
Dewatered Biosolids						
Dry Solids TSS (lbs)						
Average Annual	lbs/day	90,929				
Peak 3-Week	lbs/day	119,117				
Max Week	lbs/day	130,029				
Peak Day	lbs/day	148,215				
Dry Solids TSS (tons)						
Average Annual	dt/d	45				
Peak 3-Week	dt/d	60				
Max Week	dt/d	56				
Peak Day	dt/d	74				
Dry Solids VSS (lbs)						
Average Annual	lbs/day	54,073				
Peak 3-Week	lbs/day	70,836				
Max Week	lbs/day	77,325				
Peak Day	lbs/day	88,139				
Wet Cake (lbs)						
Average Annual	wet lbs/day	343,129				
Peak 3-Week	wet lbs/day	449,499				
Max Week	wet lbs/day	490,675				
Peak Day	wet lbs/day	559,301				
Wet Cake (tons)						
Average Annual	wet ton/day	172				
Peak 3-Week	wet ton/day	225				
Max Week	wet ton/day	245				
Peak Day	wet ton/day	280				

Table 2.3
Digester Capacity Extension Analysis

Anaerobic Mesophillic Digesters			
Evaluation Criteria			
1 Annual average flow w/ 1 digester out of service + 1/2 of the BST volume added, DT >,= 21 days			
Volume of 4 digesters + 1/2 BST	gal	8,832,166	
Acceptable average sludge flow is equal to	gpd	420,579	
2 Peak Day flow w/ all Digesters in service, DT >, = 15 days			
Total Volume	gal	10,336,900	
Acceptable peak sludge flow =	gpd	689,127	
therefore average flow =	gpd	453,372.82	governs
Convert to Annual Average influent	mgd	#REF!	
Year ESRP to Reach this flow	YR	2018	

ALTERNATIVE 1 - CENTRIDRY DRYING

Table 3.1
Alternative 1 Assumptions

			Info Source
Volatile Solids Reduction in Digesters	percent	61.0%	11
Dewatering Solids Capture	percent	95.0%	18
Centridry Dried Cake Solids	percent solids	55.0%	18
Nominal Dried Product Capacity	lbs/hr	3000	18
Number of Centridry Trains		3	
Digestion numbers from Table 2.2, Alternative 0			

Table 3.2
Centridry Dewatering Flows and Loads

	Flow gpm	TSS lbs/day	VSS lbs/day	Concentration % solids
Loading in 2009				
Average Annual	280	95,715	56,919	2.85%
Max 3-Week	366	125,387	74,564	2.85%
Max Week	400	136,872	81,394	2.85%
Peak Day	456	156,015	92,778	2.85%
Centridry Dewatering/Drying				
Number of Units	no.	3.0		
Nominal Size	model	CD3074		
Nominal Dewatering Capacity	dry lbs/hr	3000		
Total Dewatering Capacity	dry lbs/day	216,000		
Heat Demand	BTU/hr	36906530		
Operating Units at Annual Average Condition	no.	1.3		
Operating Units at Max 3-week Condition	no.	1.7		
Operating Units at Max Week Condition	no.	1.9		
Operating Units at Peak Day Condition	no.	2.2		
Dewatered Biosolids				
Dry Solids TSS in 2009 (lbs)				
Average Annual	lbs/day	90,929		
Peak 3-Week	lbs/day	119,117		
Max Week	lbs/day	130,029		
Peak Day	lbs/day	148,215		
Dry Solids TSS in 2009 (tons)				
Average Annual	tons/day	45		
Peak 3-Week	tons/day	60		
Max Week	tons/day	65		
Peak Day	tons/day	74		
Dry Solids VSS in 2009 (lbs)				
Average Annual	lbs/day	54,073		
Peak 3-Week	lbs/day	70,836		
Max Week	lbs/day	77,325		
Peak Day	lbs/day	88,139		
Wet Cake from Centridry in 2009 (lbs)				
Average Annual	wet lbs/day	165,326		
Peak 3-Week	wet lbs/day	216,577		
Max Week	wet lbs/day	236,416		
Peak Day	wet lbs/day	269,481		
Wet Cake from Centridry in 2009 (tons)				
Average Annual	wet ton/day	83		
Peak 3-Week	wet ton/day	108		
Max Week	wet ton/day	118		
Peak Day	wet ton/day	135		

ALTERNATIVE 2 - CENTRIDRY DEWATERING/DRYING FOLLOWED BY COMPOSTING

Table 4.1
Alternative 2 Assumptions

			Info Source
Volatile Solids Reduction in Digesters	percent	61.0%	11
Dewatering Solids Capture	percent	95.0%	18
Centridry Dried Cake Solids	percent solids	55.0%	18
Nominal Dried Product Capacity	lbs/hr	3000	18
Number of Centridry Trains		3	
Digestion numbers from Table 2.2, Alternative 0			
Centridry Loading numbers from Table 3.2, Alternative 1			

ALTERNATIVE 3 - DEWATERING WITH 2 CENTRIFUGES AND 1 CENTRIDRY

Table 5.1
Alternative 3 Assumptions

			Info Source
Volatile Solids Reduction in Digesters	percent	61.0%	11
Centrifuge Dewatering Solids Capture	percent	95.0%	12
Centrifuge Dewatered Cake Solids	percent solids	26.5%	13
Centridry Dewatering Solids Capture	percent	95.0%	18
Centridry Dewatered Cake Solids	percent solids	55.0%	18
1/3 of Solids Load to Centridry, 2/3 to Centrifuges			
Digestion Flow and Loading Numbers from Table 2.2, Alternative 0			
Centrifuge Dewatering			
Number of Units	no.	2.0	
Nominal Size	model	CP3074	Info Source
Nominal Dewatering Capacity/Centrifuge	dry lbs/hr	2,500	17
Centridry Dewatering			
Number of Units	no.	1.0	
Nominal Size	model	CD3074	
Nominal Dewatering Capacity/Centridry	dry lbs/hr	3,000	18

Table 5.2
Dewatering Loadings

	Flow gpm	TSS lbs/day	VSS lbs/day	Concentration % solids
Loading - Total				
Average Annual	280	95,715	56,919	2.85%
Max 3-Week	366	125,387	74,564	2.85%
Max Week	400	136,872	81,394	2.85%
Peak Day	456	156,015	92,778	2.85%
Loading - Total to Centrifuges	Flow gpm	TSS lbs/day	VSS lbs/day	Concentration % solids
Average Annual	186	63,810	37,946	2.85%
Max 3-Week	244	83,591	49,709	2.85%
Max Week	267	91,248	54,263	2.85%
Peak Day	304	104,010	61,852	2.85%
Loading - Total to Centridry	Flow gpm	TSS lbs/day	VSS lbs/day	Concentration % solids
Average Annual	93	31,905	18,973	2.85%
Max 3-Week	122	41,796	24,855	2.85%
Max Week	133	45,624	27,131	2.85%
Peak Day	152	52,005	30,926	2.85%

Table 5.3
Dewatered Biosolids

Centrifuges-Totals			
Dry Solids TSS (lbs)			
	Average Annual	lbs/day	60,620
	Peak 3-Week	lbs/day	79,412
	Max Week	lbs/day	86,686
	Peak Day	lbs/day	98,810
Dry Solids TSS (tons)			
	Average Annual	dt/d	30
	Peak 3-Week	dt/d	40
	Max Week	dt/d	43
	Peak Day	dt/d	49
Dry Solids VSS (lbs)			
	Average Annual	lbs/day	36,049
	Peak 3-Week	lbs/day	47,224
	Max Week	lbs/day	51,550
	Peak Day	lbs/day	58,759
Wet Cake (lbs)			
	Average Annual	wet lbs/day	228,753
	Peak 3-Week	wet lbs/day	299,666
	Max Week	wet lbs/day	327,117
	Peak Day	wet lbs/day	372,867
Wet Cake (tons)			
	Average Annual	wet ton/day	114
	Peak 3-Week	wet ton/day	150
	Max Week	wet ton/day	164
	Peak Day	wet ton/day	186
Centridry			
Dry Solids TSS (lbs)			
	Average Annual	lbs/day	30,310
	Peak 3-Week	lbs/day	39,706
	Max Week	lbs/day	43,343
	Peak Day	lbs/day	49,405
Dry Solids TSS (tons)			
	Average Annual	dt/d	15
	Peak 3-Week	dt/d	20
	Max Week	dt/d	22
	Peak Day	dt/d	25
Dry Solids VSS (lbs)			
	Average Annual	lbs/day	18,024
	Peak 3-Week	lbs/day	23,612
	Max Week	lbs/day	25,775
	Peak Day	lbs/day	29,380
Wet Cake (lbs)			
	Average Annual	wet lbs/day	55,109
	Peak 3-Week	wet lbs/day	72,192
	Max Week	wet lbs/day	78,805
	Peak Day	wet lbs/day	89,827
Wet Cake (tons)			
	Average Annual	wet ton/day	28
	Peak 3-Week	wet ton/day	36
	Max Week	wet ton/day	39
	Peak Day	wet ton/day	45

Information Sources for SolidsAltCentBasis

Reference number	Source
1	Estimated annual average wastewater flow to South Treatment Plant in design year of 2009.
2	Solids Projections spreadsheet with Bob Swarmer 10/26/01 memo peaking factors as inputs.
3	Not Used.
4	Estimated from plant data.
5	Estimated from plant data.
6	Estimated from plant data.
7	Assumes 25% of cone volume lost to grit and debris accumulation; assumtion based on plant staff observations during recent digester cleanings.
8	Estimated from BC experience.
9	From Enlargement IIIC design documents.
10	From Enlargement IIIC design documents.
11	Interpretation of Thermo-Meso pilot plant data, and oral discussions with Rick Butler
12	Interpretation of centrifuge pilot data, Summer 2001
13	Interpretation of centrifuge pilot data, Summer 2001
14	From Enlargement IIIC design documents. 41 SWD assumes cover is operated below max height to allow for some storage within digester.
15	Heat loss estimated based on current digester material and construction, and operation at mesophilic temp.
16	From Enlargement IIIC design documents.
17	Estimated dewatering centrifuge capacity provided by Humboldt (Baker Process).
18	Estimated Centridry capacity provided by Humboldt (baker Process).
19	Average of summer and winter 2009 values from Bob Swarmer Model spreadsheet
20	Average of summer and winter 2009 values from Bob Swarmer Model spreadsheet
21	Average of summer and winter 2009 values from Bob Swarmer Model spreadsheet for solids to dafts=193,754
22	Thickened solids TSS / day from average of summer and winter 2009 values from Bob Swarmer Model spreadsheet for Raw Solids to Digesters = 184, 067
23	Average of summer and winter 2009 values from Bob Swarmer Model spreadsheet for Raw Primary Sludge = 97,955

DIGESTER GAS REVENUE ANALYSIS
(Dewatering w/ Centrifuges and Aggressive Assumptions)

Table 6.1
Digester Gas Assumptions

			Info Source
Heating value of gas	BTU/cft	600	19
Net value of digester gas	$/therm	0.06	20
Average boiler efficiency	percent	70%	21

Table 6.2
Digester Gas Revenue

Average Annual Values	Units	Alternative 0	Alternative 1	Alternative 2	Alternative 3
Digester Gas Production	cft/day	1,335,410	1,335,410	1,335,410	1,335,410
Heating Value @ 600 BTU/cft	BTU/day	801,245,950	801,245,950	801,245,950	801,245,950
Heating Value	Therms/yr	2,924,548	2,924,548	2,924,548	2,924,548
Heat Required for Digestion	BTU/hr	6,664,009	6,664,009	6,664,009	6,664,009
Heat Required for Drying	BTU/hr	-	20,840,899	20,840,899	6,946,966
Total Heat Required	BTU/hr	6,664,009	27,504,908	27,504,908	13,610,976
Gas Demand	BTU/hr	-	39,292,726	39,292,726	19,444,251
Gas Demand	Therms/yr	-	3,442,043	3,442,043	1,703,316
Excess Gas Available for Sale	Therms/yr	2,924,548	(517,495)	(517,495)	1,221,231
Annual Revenue from Gas Sold	$/yr	175,473	(31,050)	(31,050)	73,274

- For digester heating, heat is generated by the heat extractors and accounted for as part of electrical demand

POLYMER COST ANALYSIS

(Dewatering w/ Centrifuges and Aggressive Assumptions)

Table 7.1
Polymer Cost Assumptions

Polymer usage for centrifuge is 25% greater than BFPs		
Polymer usage for Centridry is 25% greater than BFPs		
Polymer cost is	75	$/dt of biosolids

Table 7.2
Polymer Costs

Process Area	Alt 0 Replace BFP w/ Centrifuges	Alt 1 Replace BFP w/ Centridry Systems	Alt 2 Replace BFP w/ Centridry and Compostinc	Alt3 Replace BFP w/ 2 Centrifuges and 1 Centridry
Centrifuge Dewatering	1,244,594	-	-	829,729
Centridry Dewatering	-	1,244,594	1,244,594	414,865
Total annual cost	1,244,594	1,244,594	1,244,594	1,244,594

Table 8.1
Equipment Maintenance

O&M COST ANALYSIS
(Dewatering w/ Centrifuges and Aggressive Assumptions)

Equipment Name	Equip Purchase Cost	Annual Mainten. percent	Annual Mainten. Cost	Operating Equipment Alt 0 Replace BFP w/ Centrifuges	Alt 1 Replace BFP w/ Centridry Systems	Alt 2 Replace BFP w/ Centridry and Composting	Alt3 Replace BFP w/ 2 Centrifuges and 1 Centridry	Annual Maintenance Cost Alt 0 Replace BFP w/ Centrifuges	Alt 1 Replace BFP w/ Centridry Systems	Alt 2 Replace BFP w/ Centridry and Composting	Alt3 Replace BFP w/ 2 Centrifuges and 1 Centridry		
	($)	(%)	$/yr	No.	No.	No.	No.	No.	$/yr	$/yr	No.	$/yr	$/yr
	35,000	5%	1,750	0	0	0	0	-	-	-	-	-	-
	25,000	10%	2,500	0	0	0	0	-	-	-	-	-	-
				0	0	0	0						
	25,000	10%	2,500	0	0	0	0	-	-	-	-	-	-
	25,000	10%	2,500	0	0	0	0	-	-	-	-	-	-
	87,000	5%	4,350	0	0	0	0	-	-	-	-	-	-
	15,000	10%	1,500	0	0	0	0	-	-	-	-	-	-
	20,000	5%	1,000	0	0	0	0	-	-	-	-	-	-
	20,000	5%	1,000	0	0	0	0	-	-	-	-	-	-
	350,000	5%	17,500	0	0	0	0	-	-	-	-	-	-
	20,000	5%	1,000	0	0	0	0	-	-	-	-	-	-
	60,000	10%	6,000	0	0	0	0	-	-	-	-	-	-
	30,000	3%	900	0	0	0	0	-	-	-	-	-	-
	25,000	10%	2,500	0	0	0	0	-	-	-	-	-	-
	25,000	10%	2,500	0	0	0	0	-	-	-	-	-	-
	5,000	10%	500	0	0	0	0	-	-	-	-	-	-
	30,000	5%	1,500	0	0	0	0	-	-	-	-	-	-
	15,000	5%	750	0	0	0	0	-	-	-	-	-	-
	150,000	2%	3,000	0	0	0	0	-	-	-	-	-	-
	15,000	10%	1,500	0	0	0	0	-	-	-	-	-	-
	25,000	5%	1,250	0	0	0	0	-	-	-	-	-	-
	20,000	5%	1,000	0	0	0	0	-	-	-	-	-	-
	25,000	10%	2,500	0	0	0	0	-	-	-	-	-	-
	32,000	10%	3,200	0	0	0	0	-	-	-	-	-	-
								-	-	-	-	-	-
Dewatering Equipment													
Centrifuge	500,000	5%	25,000	2	0	0	1.33	50,000	-	-	33,250	-	-
Centridry	1,000,000	5%	50,000	0	2	2	0.67	-	100,000	100,000	33,500	-	-
Centrifuge/Centridry feed pump	45,000	10%	4,500	2	2	2	2	9,000	9,000	9,000	9,000	-	-
Polymer feed pump	7,500	10%	750	2	2	2	2	1,500	1,500	1,500	1,500	-	-
Subtotal (Dewatering)								60,500	110,500	110,500	77,250	-	-
Total Annual Maintenance Cost								$ 60,500	$ 110,500	$ 110,500	$ 77,250	$ -	$ -

Table 8.2
Operating Labor Cost

			Annual Labor Cost Alternative 0	Alternative 1	Alternative 2	Alternative 3
		No of tanks	0	0	0	0
		Annual Labor	$ -	$ -	$ -	$ -
Operating Labor for Centrifuge Dewatering						
Cost per FTE	$ 74,150	No. of Centrifuges	3	3	3	3
		Est. no. of FTEs	5	5	5	6
		Annual Labor	$ 370,750	$ 370,750	$ 370,750	$ 444,900

Table 9.1
Electrical Costs

ELECTRICAL COST ANALYSIS
(Dewatering w/ Centrifuges and Aggressive Assumptions)

Equipment Name	HP (name plate)	HP draw (estimate)	Operating Equipment: Alt 0 Replace BFP w/ Centrifuges No.	Alt 1 Replace BFP w/ Centridry Systems No.	Alt 2 Replace BFP w/ Centridry and Composting No.	Alt3 Replace BFP w/ 2 Centrifuges and 1 Centridry No.	Constant Electricity Usage: Alt 0 Replace BFP w/ Centrifuges HP draw	Alt 1 Replace BFP w/ Centridry Systems HP draw	Alt 2 Replace BFP w/ Centridry and Composting HP draw	Alt3 Replace BFP w/ 2 Centrifuges and 1 Centridry HP draw
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
	0	0	0	0	0	0				
							-	-	-	-
							-	-	-	-
							$ -	$ -	$ -	$ -
Dewatering Equipment										
Centrifuges main drive	125	87	1.6	0.0	0.0	1.1				
Centrifuges back drive	30	24	1.6	0.0	0.0	1.1				
Centridry	480	320	0.0	1.6	1.6	0.5				
Centrifuge feed sludge pump	30	20	1.6	1.6	1.6	1.6				
Polymer feed pump	2	1	1.6	1.5	1.5	1.6				
Conveyors	5	3	2.0	2.0	2.0	2.0	6	6	6	6
Total Hp Dewatering							6	6	6	6
Total electricity draw (kW)							4.47	4.47	4	4
Total cost/yr Dewatering							$ 2,508	$ 2,508	$ 2,508	$ 2,508

Cost of Electricity	0.064 $/kW-hr

* Equipement horsepower requirements vary depending on alternative selected. Brake horsepower requirements and pump requirements shown under the same column headings. Brake horsepower requirements shown as the first number.

		Variable Electricity Usage			
		Alt 0 Replace BFP w/ Centrifuges HP draw	Alt 1 Replace BFP w/ Centridry Systems HP draw	Alt 2 Replace BFP w/ Centridry and Composting HP draw	Alt3 Replace BFP w/ 2 Centrifuges and 1 Centridry HP draw
		-	-	-	-
		-	-	-	-
		$ -	$ -	$ -	$ -
		139	0	0	93
		38	0	0	26
		0	512	512	171
		32	32	32	32
		2	2	2	2
-	-	211	546	546	322
-	-	157	407	407	240
$ -	$ -	$ 88,034	$ 228,057	$ 228,057	$ 134,708

able 10.1
apital Cost Estimate

CAPITAL AND ANNUAL COST ANALYSIS
(Dewatering w/ Centrifuges and Aggressive Assumptions)

igestion

ategory	Alternative 0	Alternative 1	Alternative 2	Alternative 3
ite Work / Demolition	0	0	0	0
tructures	0	0	0	0
quipment & Mech	0	0	0	0
lectrical/ I&C	0	0	0	0
esting/ Start-up	0	0	0	0
ontractor Indirects, OH@P	0	0	0	0
ontingency	0	0	0	0
ales tax	0	0	0	0
Subtotal	-	-	-	-
llied Cost (35%)	-	-	-	-
Total	-	-	-	-

ewatering and Composting

	Cost, dollars			
Item	Alternative 0	Alternative 1	Alternative 2	Alternative 3
elt Press Demolition and Construction Sequencing	1,140,000	1,675,000	1,675,000	535,000
nstall new centrifuges	4,040,000	-	-	-
nstall new Centridry/centrifuge system(s)	-	9,600,000	9,600,000	6,700,000
ew Electrical Facilities	1,360,000	3,010,000	3,155,000	2,110,000
elocate Scrubbers to composting	-	-	905,000	-
ard Modifications	25,000	25,000	25,000	25,000
Subtotal	6,565,000	14,310,000	15,360,000	9,370,000
% contingency on Centridry / Centrifuge equip	105,000	350,000	350,000	215,000
5% contingency on balance of work	1,120,000	1,720,000	2,070,000	1,285,000
Subtotal	7,790,000	16,380,000	17,780,000	10,870,000
omposting facility (including contingencies)	-	-	5,350,000	-
Subtotal	7,790,000	16,380,000	23,130,000	10,870,000
esting and commissioning (2 percent)	160,000	330,000	460,000	215,000
ontractor overhead and profit (15 percent)	1,190,000	1,450,000	2,410,000	1,205,000
onds and insurance (4 percent)	370,000	730,000	1,040,000	490,000
Subtotal	9,510,000	18,890,000	27,040,000	12,780,000
asington State sales tax (8.6 percent)	820,000	1,620,000	2,320,000	1,100,000
Subtotal	10,330,000	20,510,000	29,360,000	13,880,000
ing County allied costs	3,600,000	6,470,000	9,570,000	4,580,000
nitial capital cost to modify haul trucks with aeration	-	880,000	-	390,000
otal Capital Costs, 2001 dollars	13,930,000	27,860,000	38,930,000	18,850,000
otal Capital Costs, inflated to 2004 dollars	15,230,000	30,450,000	42,550,000	20,600,000

otal Capital Cost

	Alternative 0	Alternative 1	Alternative 2	Alternative 3
Grand Total Capital Expendature	$ 15,230,000	$ 30,450,000	$ 42,550,000	$ 20,600,000

Table 10.2
Annual Costs at Design Year Loading, 2010 (todays dollars)

Digestion

Category	Alternative 0	Alternative 1	Alternative 2	Alternative 3
Equipment Maintenance	$ -	$ -	$ -	$ -
Operations Labor	$ -	$ -	$ -	$ -
Power				
Fixed	$ -	$ -	$ -	$ -
Variable	$ -	$ -	$ -	$ -
Chemicals (polymer)	$ -	$ -	$ -	$ -
Gas Sale Net Revenue	$ -	$ 206,523	$ 206,523	$ 102,199
Total Annual Cost	$ -	$ 206,523	$ 206,523	$ 102,199

Dewatering/Composting

Category	Alternative 0	Alternative 1	Alternative 2	Alternative 3
Equipment Maintenance	$ 60,500	$ 110,500	$ 110,500	$ 77,250
Operations Labor	$ 370,750	$ 370,750	$ 370,750	$ 444,900
Power				
Fixed	$ 2,508	$ 2,508	$ 2,508	$ 2,508
Variable	$ 88,034	$ 228,057	$ 228,057	$ 134,708
Chemicals (polymer)	$ 1,244,594	$ 1,244,594	$ 1,244,594	$ 1,244,594
Composting	$ -	$ -	$ 594,000	$ -
Total Annual Cost	$ 1,766,387	$ 1,956,409	$ 2,550,409	$ 1,903,961

Biosolids Haul and Application

Category	Alternative 0	Alternative 1A	Alternative 1B	Alternative 1C	Alternative 2D	Alternative 2E	Alternative 2F	Alternative 3A	Alternative 3B	Alternative 3C
Avg Unit Cost/WT	$ 31.96	$ 42.52	$ 52.17	$ 40.73	$ 20.68	$ -	$ 5.00	$ 34.29	$ 36.08	$ 33.96
Biosolids Haul and Application	$ 2,122,113	$ 1,284,137	$ 1,575,471	$ 1,229,963	$ 624,648	$ -	$ 151,000	$ 1,863,276	$ 1,960,388	$ 1,845,218

**** NOTE: The above numbers were hard input, and are not exact reflections of wet cake numbers on the Alternatives sheets.
To reflect changes in cake numbers, you must change the above numbers by hand ****

Total Annual Cost (Year 2010, Todays Dollars)

Category	Alternative 0	Alternative 1A	Alternative 1B	Alternative 1C	Alternative 2D	Alternative 2E	Alternative 2F	Alternative 3A	Alternative 3B	Alternative 3C
Total Annual Cost	$ 3,888,500	$ 3,447,069	$ 3,738,403	$ 3,392,895	$ 3,381,580	$ 2,756,932	$ 2,907,932	$ 3,869,436	$ 3,966,548	$ 3,851,378
Annual Costs expected to not vary with flow	$ 433,758	$ 483,758	$ 483,758	$ 483,758	$ 483,758	$ 483,758	$ 483,758	$ 524,658	$ 524,658	$ 524,658
Annual Costs expected to vary with flow	$ 3,454,741	$ 2,963,311	$ 3,254,645	$ 2,909,137	$ 2,897,822	$ 2,273,174	$ 2,424,174	$ 3,344,777	$ 3,441,889	$ 3,326,719

able 10.3
nnual Costs by Year *

ear	Annual Average DS Production	Percentage of Year 2019 flow	Alternative 0	Alternative 1A	Alternative 1B	Alternative 1C	Alternative 2D	Alternative 2E	Alternative 2F	Alternative 3A	Alternative 3B	Alternative 3C
005	91.3	95.4%	3,729,661	3,310,825	3,588,764	3,259,142	3,248,347	2,652,419	2,796,476	3,715,653	3,808,300	3,698,425
006	92.4	96.6%	3,769,371	3,344,886	3,626,174	3,292,580	3,281,655	2,678,547	2,824,340	3,754,099	3,847,862	3,736,663
007	93.5	97.7%	3,809,080	3,378,947	3,663,584	3,326,019	3,314,964	2,704,675	2,852,204	3,792,544	3,887,424	3,774,902
008	94.6	98.9%	3,848,790	3,413,008	3,700,994	3,359,457	3,348,272	2,730,804	2,880,068	3,830,990	3,926,986	3,813,140
009	95.7	100.0%	3,888,500	3,447,069	3,738,403	3,392,895	3,381,580	2,756,932	2,907,932	3,869,436	3,966,548	3,851,378
010	92.1	96.2%	3,758,541	3,335,597	3,615,972	3,283,461	3,272,571	2,671,421	2,816,741	3,743,613	3,837,072	3,726,235
011	93.3	97.5%	3,801,860	3,372,754	3,656,782	3,319,939	3,308,908	2,699,925	2,847,138	3,785,554	3,880,231	3,767,949
012	94.5	98.7%	3,845,180	3,409,912	3,697,593	3,356,417	3,345,244	2,728,429	2,877,535	3,827,495	3,923,389	3,809,663
013	95.7	100.0%	3,888,500	3,447,069	3,738,403	3,392,895	3,381,580	2,756,932	2,907,932	3,869,436	3,966,548	3,851,378
014	95.2	99.5%	3,870,450	3,431,587	3,721,399	3,377,696	3,366,440	2,745,056	2,895,267	3,851,961	3,948,565	3,833,997
015	94.7	99.0%	3,852,400	3,416,105	3,704,394	3,362,497	3,351,300	2,733,179	2,882,601	3,834,485	3,930,582	3,816,616
016	94.2	98.4%	3,834,350	3,400,622	3,687,390	3,347,298	3,336,160	2,721,303	2,869,936	3,817,010	3,912,600	3,799,235
017	93.7	97.9%	3,816,300	3,385,140	3,670,386	3,332,098	3,321,020	2,709,426	2,857,270	3,799,535	3,894,617	3,781,854
018	93.3	97.5%	3,801,860	3,372,754	3,656,782	3,319,939	3,308,908	2,699,925	2,847,138	3,785,554	3,880,231	3,767,949
019	92.8	97.0%	3,783,810	3,357,272	3,639,778	3,304,740	3,293,768	2,688,048	2,834,472	3,768,079	3,862,248	3,750,568

* Annual cost for each year is calculated as the sum of the fixed annual cost plus the variable annual cost prorated on flow.

PRESENT WORTH COST ANALYSIS

Table 11.1
Life Cycle Costs

		Alternative 0	Alternative 1A	Alternative 1B	Alternative 1C	Alternative 2D	Alternative 2E	Alternative 2F
Inflated Annual Costs	inflation							
Year	years							
2005	4	4,197,766	3,726,363	4,039,186	3,668,193	3,656,043	2,985,320	3,147,458
2006	5	4,369,734	3,877,640	4,203,730	3,817,003	3,804,338	3,105,170	3,274,184
2007	6	4,548,241	4,034,640	4,374,511	3,971,440	3,958,240	3,229,524	3,405,681
2008	7	4,733,526	4,197,570	4,551,755	4,131,708	4,117,952	3,358,544	3,542,121
2009	8	4,925,835	4,366,644	4,735,697	4,298,018	4,283,685	3,492,399	3,683,682
2010	9	4,904,043	4,352,197	4,718,023	4,284,171	4,269,963	3,485,599	3,675,208
2011	10	5,109,382	4,532,700	4,914,409	4,461,720	4,446,895	3,628,473	3,826,315
2012	11	5,322,628	4,720,115	5,118,333	4,646,066	4,630,600	3,776,783	3,983,182
2013	12	5,544,071	4,914,697	5,330,069	4,837,457	4,821,325	3,930,726	4,146,016
2014	13	5,683,886	5,039,401	5,465,000	4,960,261	4,943,731	4,031,207	4,251,797
2015	14	5,827,101	5,167,165	5,603,229	5,086,078	5,069,142	4,134,179	4,360,193
2016	15	5,973,792	5,298,059	5,744,834	5,214,981	5,197,628	4,239,701	4,471,267
2017	16	6,124,042	5,432,156	5,889,891	5,347,040	5,329,262	4,347,833	4,585,080
2018	17	6,283,896	5,574,649	6,044,104	5,487,353	5,469,120	4,462,564	4,705,885
2019	18	6,441,684	5,715,531	6,196,478	5,626,098	5,607,419	4,576,222	4,825,500
PW Annual Costs		39,703,853	35,217,570	38,185,391	34,665,700	34,550,434	28,187,142	29,725,380
PW Capital Costs		13,930,000	27,860,000	27,860,000	27,860,000	38,930,000	38,930,000	38,930,000
Total Present Worth		53,633,853	63,077,570	66,045,391	62,525,700	73,480,434	67,117,142	68,655,380

Alternative 3A	Alternative 3B	Alternative 3C
4,182,000	4,286,275	4,162,610
4,352,029	4,460,727	4,331,817
4,528,496	4,641,787	4,507,430
4,711,635	4,829,697	4,689,681
4,901,686	5,024,704	4,878,810
4,884,567	5,006,509	4,861,891
5,087,468	5,214,706	5,063,809
5,298,148	5,430,888	5,273,465
5,516,890	5,655,349	5,491,144
5,656,734	5,798,601	5,630,354
5,800,003	5,945,359	5,772,974
5,946,777	6,095,703	5,919,084
6,097,138	6,249,717	6,068,765
6,256,944	6,413,430	6,227,846
6,414,902	6,575,219	6,385,091
39,528,866	40,518,146	39,344,909
18,850,000	18,850,000	18,850,000
58,378,866	59,368,146	58,194,909

J

TAB

APPENDIX J

LETTER FROM BRIAN LENT, BIRD MACHINE COMPANY (BAKER PROCESS), OCTOBER 3, 2001

BIRD MACHINE COMPANY

HUMBOLDT CENTRIPRESS
CENTRIDRY

Oct. 3, 2001

Mr. Gary Newman
Brown & Caldwell
Wells Fargo Center
999 Third Ave, Suite 500
Seattle, WA. 98104-4012

Subject: Response to the Letter dated March 20,2001
Centridry Product Evaluation Project
King County Department of Natural Resources

Dear Mr. Newman:

Gary, sorry for the delay getting the information to you. Humboldt is now part of Baker Hughes assigned to the Bird Centrifuge group. The Centridry information is still co-ordinated from Cologne.

Attached is the information you requested on the Renton Centridry project.

The pricing associated with the attached Alternatives are:

Alternatives 1&2:	3 Centridry systems	$ 7,084,600.00
	Includes all equipment, electrical panels and commissioning	
Alternative 3:	1 Centridry system and 2 Centripress units capable of upgrade to Centridry Systems	$ 4,152,000.00
	Includes all equipment, electrical panels and commissioning	
Pricing does not include freight or applicable taxes		

The data is included in the Memo from Mr. Schnabel from Cologne.

If you have any questions please feel free to call me at the San Ramon Ca. Office (925) 830 – 1578 or E-mail brian.lent@bakerhughes.com.

Regards

Brian Lent

Brian Lent
Manager-Field Services
Municipal

Humboldt / BIRD 2206 Camino Ramon, San Ramon, CA. 94583
Tel: 925 830-1578 / Fax: 925 830-9071

Memorandum

BAKER HUGHES

BAKER PROCESS

TO: BROWN AND CALDWELL

FROM: Wilfried Schnabel, Baker Process Cologne

DATE: 24. August 2001

RE: Project Centridry Installation at King County WWRP, Renton

1 Bases of the following information are:

Letter from Brown and Coldwell, dated March 20, 2001

Previous conceptions and data for this project worked out in 1998

Alternatives:

- Centridry size will be identical for the **Alternatives 1 and 2**. There is only different treatment of the product after drying. 3 Centridry CD3074 streams are needed for the required evaporation capacity based on the 2010 max. dry solids (81.8 US-tons per day). Starting 2005 the plant will be oversized, thus enough stand-by will be available. If a complete stand-by stream is required an additional (4th) stream must be installed in an extra building. All Centridry will be designed to be used for both dewatering and drying operation. All required information and data see below and attached.
- Alternative 3: We recommend to install 2 high solid centrifuges CENTRIPRESS CP3074 plus 1 Centridry CD3074 - used for both drying and dewatering. 1 machine would be stand-by: 1 CENTRIPRESS plus 1 Centridry duty, 1 CENTRIPRESS standby. Or 2 CENTRIPRESS duty, 1 Centridry stand-by able to dewater.
  This proposed arrangement would be open to change one more or both CENTRIPRESS to Centridry when needed.

2 Requested information

2.1 Sizing

Centridry streams are designed for 7 days per week / 24 hours per day operation.

The Centridry machines are designed to operate in two modes:

Drying: Using the whole installed system to produce dried sludge with a dry solids content of app. 55%.

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Dewatering: After exchanging some items the Centridry machines operate like CENTRIPRESS CP 3074 producing sludge cake with a dry solids content of app. 24%.

2.2 Centridry performance

2.2.1 Design capacities

Regarding the Centridry throughput we refer to the attached table "capacity_30.xls" (sludge feed with 3.0% dry solids) and "capacity_32.xls" (sludge feed with 3.2% dry solids). For processing the average digested sludge production only 2 dryer streams will be needed and the 3rd stream will only be in operation during peek production week(s). So we assume that the installation of 3 stream may fulfil the stand-by requirements.

2.2.2 Polymer consumption

Regarding the expected polymer consumption we refer to the attached table "capacity_30.xls" (sludge feed with 3.0% dry solids) and "capacity_32.xls" (sludge feed with 3.2% dry solids). Assumed that the sludge conditions are comparable to those during the Centridry test period September 1997 to March 1998.

2.2.3 Electrical power consumption

Regarding the electrical power consumption of each item we refer to the attached table "power_loads.xls".

2.2.4 Fuel consumption

Regarding the fuel consumption we refer to the attached table "capacity_30.xls" (sludge feed with 3.0% dry solids) and "capacity_32.xls" (sludge feed with 3.2% dry solids).
The burner efficiency (hot gas generator) is expected with >99%.

Fuel consumption calculation is based on digester gas with 600 BTU per cu.ft.. The H_2S and the Sulfor content must be compliant with the statutory emission regulations in order to not exceed the SO_2 emission limit.

2.2.5 Mass balance

Regarding mass balance we generally refer to the attached table "balance.xls" and the related principle PFD "renton_cd_pfd.xls".
We expect a venturi scrubber efficiency of app. 60% regarding ammonium. It depends on the sludge contents. The solids content of the waste air behind the scrubber will be 5 to 10 milligrams per m^3.

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2.2.6 Recovery efficiencies

Dewatering centrifuge	max. 98%
Separation cyclone	99 to 99.5%

2.3 Utility water demand

Regarding utility water demand we refer to the attached table "capacity_30.xls" (sludge feed with 3.0% dry solids) and "capacity_32.xls" (sludge feed with 3.2% dry solids).

2.4 Structural loadings

Regarding dead loads and live loads we refer to the attached table "power_loads.xls". Regarding dynamic loads we refer to the table "dyn_loads.xls".

3 Capital costs

to be supplied.

4 Labor estimation

Operating: A 3 stream Centridry plant can be operated by 1 operator at a Central Control Room (CCR) with support by labatory works for analysis etc. As operating the CD Demonstration Project showed the manning level depends on how the dried product handling/loading is organised. Experiences with operating plants show that a 1 resp. 2 shift opertion personnel is possible if the product handling is automated.

Maintenance: Based on experiences we expect maintenance/spare parts costs of app. 1.5% of the capital per year as an average of long time operation.

When Centridry is changed to dewatering operation additional manning may be required.

5 Layout

See attached layout drawings. The layout is based on a 3 stream Centridry CD3074 plant. If more stand-by capacity is required a 4th stream must be installed in an extra building or building extension. When knowing more details of the available building the piping and thus the required height of the plant should be optimized.

6 Full scale project versus CD Demonstration Project

Basic values regarding sludge conditions and sludge behavior during dewatering and drying were used for determining the thermal calculation. The drying process calculation is based on the assumed sludge cake with 24% DS as mentioned in the B&C letter dated March 19, 2001.

The dewatering trials as well as the operation of the Demonstration Plant showed that the specific sludge condition of South Treatment Plant (former ESRP) require more polymer usage as common digested sludge. The recorded polymer consumption during the trial period from September 1997 to March 1998 variied between 25 (minimum) and a peek value of app. 50 #/dry ton with an average of 32 #/dry ton. It must assumed that this polymer consumption will be nessecary to achieve sufficient dewatering and centrate quality results.

As important as the trial results are the experiences Baker Process got meanwhile from the plants running with the CD3074. For sizing these experiences are determining the plant details of the plant design more than the small Demonstration plant. Modifications regarding design and control have been made considering the scale-up factor of nearly 5.

Project: **Centridry King County WWRP**

Main Flow Parameters

Date: **8/24/01**

Revison: **0**

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BAKER PROCESS

	Alternative 1 and 2 2005/Ave				Alternative 1 and 2 2010/Ave.				Alternative 1 and 2 2005/Max.				Alternative 1 and 2 2010/Max.			
Input																
digested solids	tons/day	50.2			tons/day	76.3			tons/day	53.8			tons/day	81.8		
digested solids	#/hr	4184	kg/h	1898	#/hr	6360	kg/h	2885	#/hr	4485	kg/h	2034	#/hr	6818	kg/h	3093
sludge flow	gpm	279	m³/h	63.3	gpm	423	m³/h	96.2	gpm	299	m³/h	67.8	gpm	454	m³/h	103.1
feed solids content	%	3.0%	%	3.0%	%	3.0%	%	3.0%	%	3.0%	%	3.0%	%	3.0%	%	3.0%
Dewatering																
recovery	%	98%	%	98%	%	98%	%	98%	%	98%	%	98%	%	98%	%	98%
solids	#/hr	4101	kg/h	1860	#/hr	6233	kg/h	2827	#/hr	4395	kg/h	1993	#/hr	6682	kg/h	3031
% cake	%	24.0%	%	24.0%	%	24.0%	%	24.0%	%	24.0%	%	24.0%	%	24.0%	%	24.0%
cake wet	#/hr	17086	kg/h	7750	#/hr	25970	kg/h	11780	#/hr	18312	kg/h	8306	#/hr	27842	kg/h	12629
water	#/hr	12986	kg/h	5890	#/hr	19737	kg/h	8953	#/hr	13917	kg/h	6313	#/hr	21160	kg/h	9598
Drying																
% cake	%	55.0%	%	55.0%	%	55.0%	%	55.0%	%	55.0%	%	55.0%	%	55.0%	%	55.0%
cake wet	#/hr	7456	kg/h	3382	#/hr	11332	kg/h	5140	#/hr	7991	kg/h	3625	#/hr	12149	kg/h	5511
water	#/hr	3355	kg/h	1522	#/hr	5100	kg/h	2313	#/hr	3596	kg/h	1631	#/hr	5467	kg/h	2480
water evaporation	#/hr	9631	kg/h	4368	#/hr	14638	kg/h	6640	#/hr	10321	kg/h	4682	#/hr	15693	kg/h	7118
water evaporation per unit	#/hr	4815	kg/h	2184	#/hr	4879	kg/h	2213	#/hr	5161	kg/h	2341	#/hr	5231	kg/h	2373
units installed		3				3				3				3		
units duty		2				3				2				3		
machine type		CD 3074				CD 3074				CD 3074				CD 3074		
consumption data																
total electrical power consumption			kW	630			kW	975			kW	630			kW	990
total electrical power installed			kW	1650			kW	1650			kW	1650			kW	1650
total thermal consumption	BTU/hr	13711836	kW	4019	BTU/hr	20840899	kW	6108	BTU/hr	14695155	kW	4307	BTU/hr	22343192	kW	6549
heating value	BTU/cu.f	600	MJ/m³	24.0	BTU/cu.f	600	MJ/m³	24.0	BTU/cu.f	600	MJ/m³	24.0	BTU/cu.f	600	MJ/m³	24.0
gas consumption	ft³/hr	22853	m³/h	603	ft³/hr	34735	m³/h	916	ft³/hr	24492	m³/h	646	ft³/hr	37239	m³/h	982
total cooling water demand	gpm	731	m³/h	166	gpm	1097	m³/h	249	gpm	731	m³/h	166	gpm	1097	m³/h	249
polymer consumption	similar to test with CD 1-1.1				similar to test with CD 1-1.1				similar to test with CD 1-1.1				similar to test with CD 1-1.1			
expected at normal conditions	#/dry ton	app. 30	kg/to DS	app. 15	#/dry ton	app. 30	kg/to DS	app. 15	#/dry ton	app. 30	kg/to DS	app. 15	#/dry ton	app. 30	kg/to DS	app. 15
expected peek conditions	#/dry ton	app. 40	kg/to DS	app. 20	#/dry ton	app. 40	kg/to DS	app. 20	#/dry ton	app. 40	kg/to DS	app. 20	#/dry ton	app. 40	kg/to DS	app. 20

Wilfried Schnabel

'roject: **Centridry King County WWRP**

Main Flow Parameters

)ate: **8/24/01**

levison: **0**

BAKER HUGHES

BAKER PROCESS

	Alternative 1 and 2 2005/Ave				Alternative 1 and 2 2010/Ave.				Alternative 1 and 2 2005/Max.				Alternative 1 and 2 2010/Max.			
Input																
ligested solids	tons/day	50.2			tons/day	76.3			tons/day	53.8			tons/day	81.8		
figested solids	#/hr	4184	kg/h	1898	#/hr	6360	kg/h	2885	#/hr	4485	kg/h	2034	#/hr	6818	kg/h	3093
iludge flow	gpm	261	m^3/h	59.3	gpm	397	m^3/h	90.2	gpm	280	m^3/h	63.6	gpm	426	m^3/h	96.7
'eed solids content	%	3.2%	%	3.2%	%	3.2%	%	3.2%	%	3.2%	%	3.2%	%	3.2%	%	3.2%
Dewatering																
ecovery	%	98%	%	98%	%	98%	%	98%	%	98%	%	98%	%	98%	%	98%
olids	#/hr	4101	kg/h	1860	#/hr	6233	kg/h	2827	#/hr	4395	kg/h	1993	#/hr	6682	kg/h	3031
% cake	%	24.0%	%	24.0%	%	24.0%	%	24.0%	%	24.0%	%	24.0%	%	24.0%	%	24.0%
ake wet	#/hr	17086	kg/h	7750	#/hr	25970	kg/h	11780	#/hr	18312	kg/h	8306	#/hr	27842	kg/h	12629
vater	#/hr	12986	kg/h	5890	#/hr	19737	kg/h	8953	#/hr	13917	kg/h	6313	#/hr	21160	kg/h	9598
)rying																
% cake	%	55.0%	%	55.0%	%	55.0%	%	55.0%	%	55.0%	%	55.0%	%	55.0%	%	55.0%
ake wet	#/hr	7456	kg/h	3382	#/hr	11332	kg/h	5140	#/hr	7991	kg/h	3625	#/hr	12149	kg/h	5511
vater	#/hr	3355	kg/h	1522	#/hr	5100	kg/h	2313	#/hr	3596	kg/h	1631	#/hr	5467	kg/h	2480
vater evaporation	#/hr	9631	kg/h	4368	#/hr	14638	kg/h	6640	#/hr	10321	kg/h	4682	#/hr	15693	kg/h	7118
vater evaporation per unit	#/hr	4815	kg/h	2184	#/hr	4879	kg/h	2213	#/hr	5161	kg/h	2341	#/hr	5231	kg/h	2373
nits installed		3				3				3				3		
nits duty		2				3				2				3		
nachine type		CD 3074				CD 3074				CD 3074				CD 3074		
onsumption data																
tal electrical power consumption			kW	630			kW	975			kW	630			kW	990
tal electrical power installed			kW	1650			kW	1650			kW	1650			kW	1650
tal thermal consumption	BTU/hr	13711836	kW	4019	BTU/hr	20840899	kW	6108	BTU/hr	14695155	kW	4307	BTU/hr	22343192	kW	6549
eating value	BTU/cu.f	600	MJ/m^3	24.0	BTU/cu.f	600	MJ/m^3	24.0	BTU/cu.f	600	MJ/m^3	24.0	BTU/cu.f	600	MJ/m^3	24.0
is consumption	ft^3/hr	22853	m^3/h	603	ft^3/hr	34735	m^3/h	916	ft^3/hr	24492	m^3/h	646	ft^3/hr	37239	m^3/h	982
tal cooling water demand	gpm	731	m^3/h	166	gpm	1097	m^3/h	249	gpm	731	m^3/h	166	gpm	1097	m^3/h	249
olymer consumption	similar to test with CD 1-1.1				similar to test with CD 1-1.1				similar to test with CD 1-1.1				similar to test with CD 1-1.1			
expected at normal conditions	#/dry ton	app. 30	kg/to DS	app. 15	#/dry ton	app. 30	kg/to DS	app. 15	#/dry ton	app. 30	kg/to DS	app. 15	#/dry ton	app. 30	kg/to DS	app. 15
expected peek conditions	#/dry ton	app. 40	kg/to DS	app. 20	#/dry ton	app. 40	kg/to DS	app. 20	#/dry ton	app. 40	kg/to DS	app. 20	#/dry ton	app. 40	kg/to DS	app. 20

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BAKER PROCESS

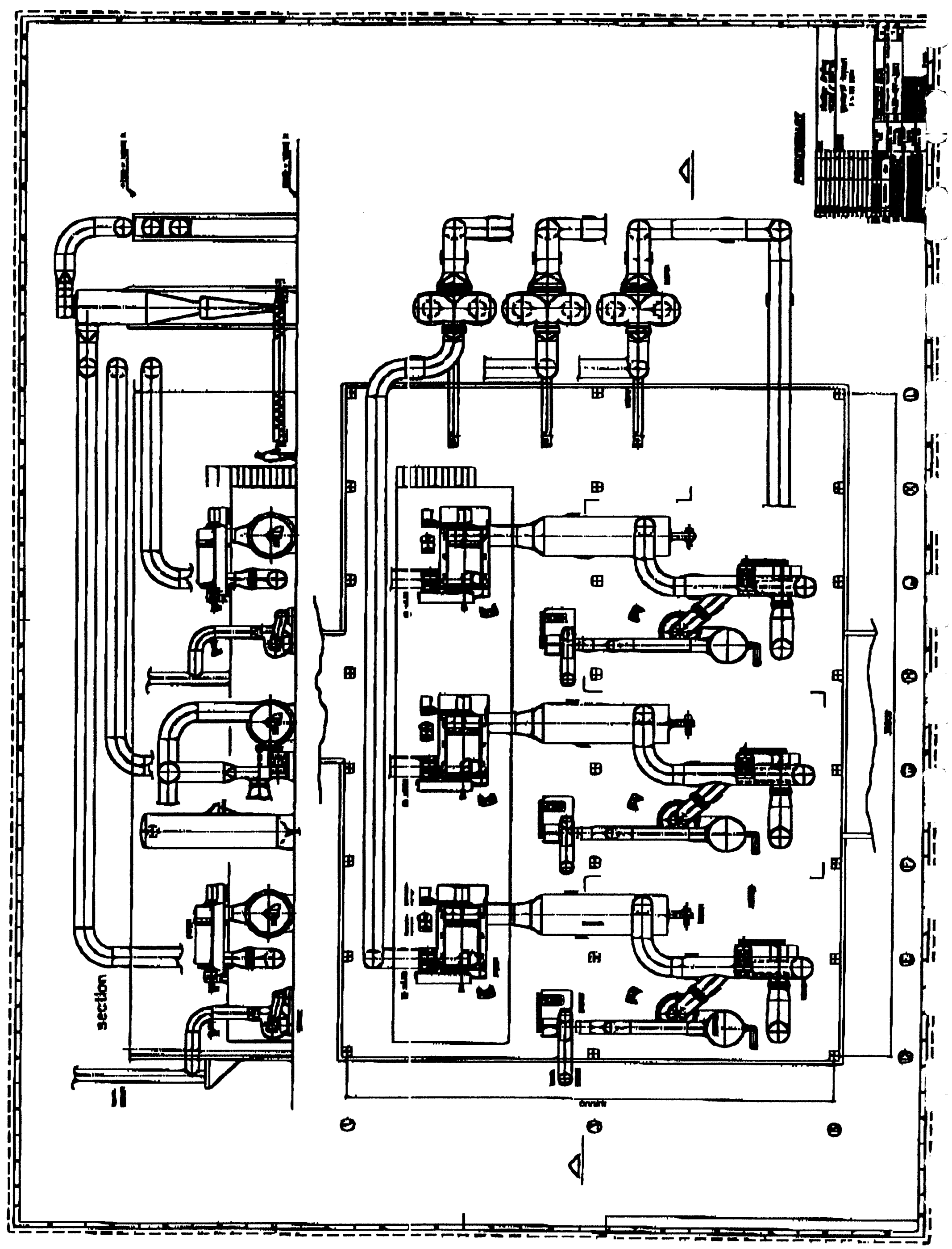
Data sheet to PFD

34.4	m3/h Thin Sludge with	3.0	% TS	Remarks: CD 3074
	DS Throughput	1032	kgTS/h	
	Dewatered by CENTRIPRESS to	24	% TS	
	Dried to	55	% TS	
	Resulting evaporation	2.39	t/h	

Path		DUI	GL	Zentrat	T3	W3	W8
Description	Unit	Thin sludge	Flocculant	Centrate	Dried sludge	Cooling Water	Effluent
Temperature	°C	20	20	25	70	20	52
Mass flow	kg/h	34400	3096	33257	1850	53038	53038
Volume	m3/h	34.4	3.10	33.3	3.7	53.0	53.0
DS Content	%TS	3	0.2	0.062	55		

Path		B	L1	R4	R6	R7	R9
Description	Unit	digester gas	Air	Flue gas	Flue gas	Flue gas	Flue gas
Temperature	°C	20	15	250	150	130	141
Pressure	hPa (ü)		0	-5	-55	-70	1
Mass flow	kg/h		3,085	45,959	48,842	49,657	6,943
Volume, actual	Bm3/h		2,562	84,169	76,865	75,820	10,110
Volume, normal conditions	Nm3/h	327.0	2,395	43,121	46,236	47,109	6,587
Density	kg/Bm3		1.20	0.55	0.64	0.65	0.69
Humidity	g/kg		6	597	641	651	651

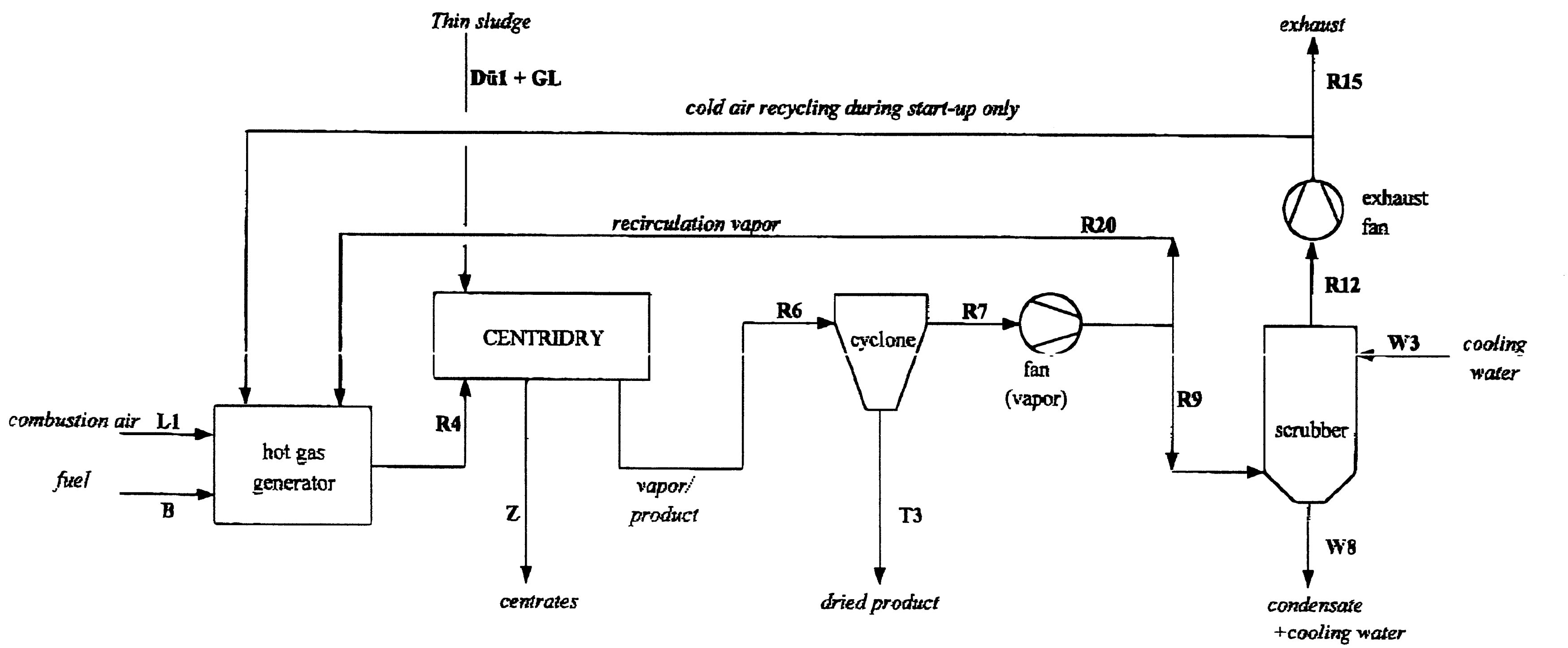
Path		R14	R15	R20
Description	Einheit	Flue gas	Flue gas	Flue gas
Temperature	°C	30	36	141
Pressure	hPa (ü)	-44	1	0
Mass flow	kg/h	4,324	4,324	42,714
Volume, actual	Bm3/h	3,918	3,812	62,261
Volume, normal conditions	Nm3/h	3,328	3,328	40,523
Density	kg/Bm3	1.10	1.13	0.69
Humidity	g/kg	28	28	651


section

BAKER HUGHES

Baker Process

CENTRIDRY - Renton



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8/28/01
Renton_cd_pfd.xls

Project: **Centridry King County WWRP**

Date: **8/24/01**

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BAKER HUGHES

BAKER PROCESS

Weights/Loads/Electrical Power of Aggregates (1)

one CD 3074 plant, water evaporation ca. 2.4 t/hr (5300 #/hr), data preliminary

aggregate	no. in p&i	installed electrical power kW	consumption electrical power kW	weight empty kg	weight empty lb	weight in oper. kg	weight in oper. lb	weight, worst case kg	weight, worst case lb	dynamical load
CENTRIDRY 3074 Maindrive	S-301	90	65	12500	27588	13300	29353	-	-	see separate table
CENTRIDRY 3074 Backdrive	S-301	22	18							
sludge pump	P-301	22	15							
polymer pump	P-302	0.75	0.49							
cyclone	F-301	-	-	4400	9711	5500	12139	11000	24277	-
rotary lock	X-301	1.1	0.8							
screw convejor	H-301	4	2							
hot gas generator	D-301	7.5	5.5	3250	7173	3250	7173	-	-	-
fan (recycle gas)	V-302	315	212	5600	12359	5600	12359	-	-	-
fan (waste gas)	V-301	11	8	400	883	400	883	-	-	-
scrubber	F-302	-	-	4700	10373	5000	11035	19700	43478	-
water pump	P-303	18.5	10							

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BAKER PROCESS

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Dynamic Loads CD 3074 machine

dynamic loads in N (Newton), preliminary

	in vertical direction		in horizontal direction	
corner load no.	operating speed	when passing resonance	operating speed	when passing resonance
1	1395	8365	560	2790
2	1170	7020	470	2340
3	1170	7020	470	2340
4	1395	8365	560	2790

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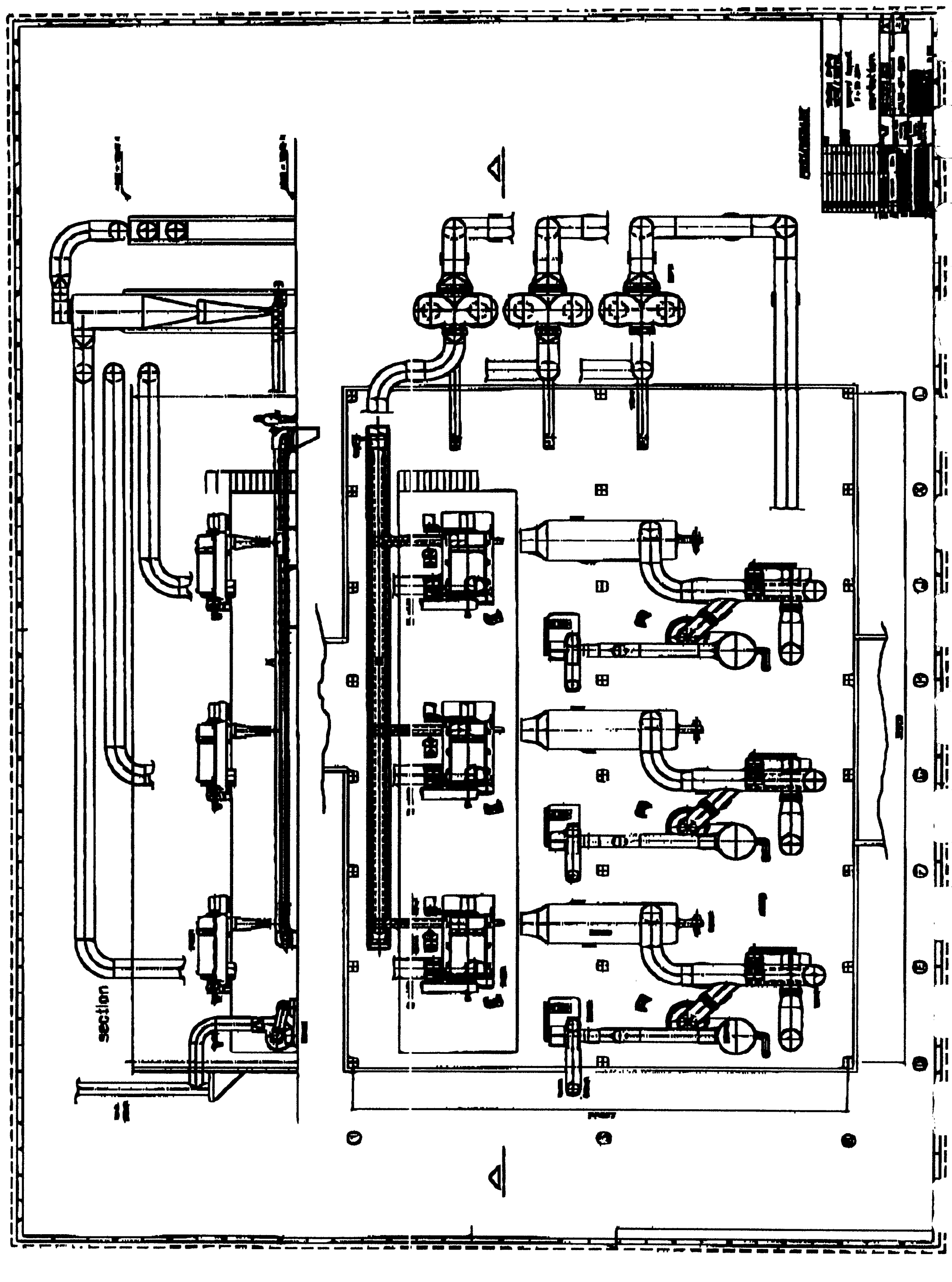
section

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TAB

APPENDIX K

KING COUNTY COMMENTS ON FINAL DRAFT REPORT AND CONSULTANT RESPONSES

Appendix K
Final Report: Centridry Demonstration and Product Evaluation Project
King County Review Comments

No.	Section	Page	Comment	Reviewer	Response
1	-	Cover	Rename cover art King County location to South Treatment Plant	Bucher	Note change
2	1	1-1	2nd paragraph of Background; 2nd sentence: WP currently produces solids at 26 to 28 percent solids.	Smyth	Text changed
3	1	1-1	3rd paragraph of Background; 2nd sentence: delete "with a 20 to 22 percent solids content".	Smyth	Text changed
4	1	1-1	3rd paragraph of Background; 3rd sentence: after "centrifuges", insert "producing 26 to 28 percent solids". After "presses", insert "producing 16 to 22 percent solids".	Smyth	Text changed
5	1	1-2	Under section titled "Experience in Europe and Japan, reference King County trip reports - Dan Grenet and Pete Machno.	Bucher	Reference added
6	1	1-3	Table 1-1 to include date provided. All data provided by Humboldt or Baker Process as of (month/year). This provides a reference date.	Bucher	Note added to table
7	1	1-4	Under key activities listed as bullets: include Technology Assessment Program (formally AWT Program) in first three bullets - construction, startup/optimization, and operation; include King County South Treatment Plant Process Lab under Composting bin tests and Centridry product analytical testing.	Bucher	Text changed
8	2	2-3	At end of Product Composting Section, the reference to see Appendix C should be C-1.	Bucher	Text changed
9	3	3-4	In Table 3-1, data column carries title of "Average value" but for Feed Solids, percent there is a range shown. Use average value.	Bucher	Text changed
10	3	3-4	In Table 3-2, data column carries title of "Average value" but for Product Bulk Density, 1b/cu yd there is a range shown. Use average value.	Bucher	Text changed
11	3	3-6	Third full paragraph discusses experience in Europe with static pile composting.....provide source of information as reference.	Bucher	Reference added
12	3	3-6 & 3-7	Use standard format for compost mix ratios (bulking material : Centridry). This will match discussions in Appendix C and eliminate confusion.	Bucher	Text changed
13	3	3-9	Under Additional Microbiological Data section, in second sentence, eliminate the words "In general".	Bucher	Text changed
14	3	3-10	Top of the page - last two sentences of the Micro section need data reference to backup. Need to summarize regrowth trial data in appendix and reference in text. King County will make an attempt to locate data and forward.	Bucher	Reference added

No.	Section	Page	Comment	Reviewer	Response
15	4	4-1	Last paragraph, 1st sentence. Even at 55-60% solids, dusting was a problem when loading and mixing the product.	Hennig	Based on extended operating experience, it was concluded that product in the 55-60% solids range does not create a dusting problem (conversation with Bob Bucher)
16	4	4-3	Under Section titled " Identify Mechanisms for Odor Generation and Methods for Controlling Odor", second sentence referencing one-day brainstorming workshop. Add date when the workshop was conducted	Bucher	Date added
17	4	4-5	Under "Follow-up Tests" - reference results in Appendix E.	Bucher	Text changed
18	5	5-3	Top paragraph. Change "28 and 32 percent" to "2.8 and 3.2 percent".	Smyth	Text changed
19	5	5-3	Last sentence in Solids Stabilization section should read "....digested sludge typically range between 2.8 and 3.2 percent; volatile solids typically range between......"	Bucher	Text changed
20	5	5-4	Last paragraph in Centridry Product Odor Control section to include short discussion of risk in installation of aeration units on King County trailers. Has it been done before? Also cost is only capital for installation? May want to add maintenance cost.	Bucher	Text has been added
21	5	5-5	Alternative 2 at the top of the page to read followed by onsite composting. This adds needed detail.	Bucher	Text changed
22	5	5-7	Figures 5-1 through 5-4 to follow Table 5-3 (table takes up 2-1/2 pages).	Bucher	Tables moved
23	5	5-7	Figure 5-3. Include "onsite" with reference to composting.	Bucher	Figure changed
24	5	5-10	Second paragraph under Alt 1 title - last sentence states that converting centrifuge from Centridry operation to centrifuge only will provide additional capacity. Is it true that design solids throughput is high on conventional centrifuge dewatering than centridry dewatering (with same size centrifuge)?	Bucher	Text changed
25	5	5-10 & 5-11	Add bullet to list of related support systems - bullet to read "Provide digester gas (with propane backup) piping to dewatering building"	Bucher	Text changed
26	5	5-13 & 5-14	page ordering is backwards.	Bucher	Page order OK
27	7	7-2	Second paragraph under Centridry Process section - add sentence stating that demonstration Centridry unit was granted a permanent air permit by PSCAA in 1999.	Bucher	Text changed

No.	Section	Page	Comment	Reviewer	Response
28	7	7-4	1sr 2 paragraphs. GroCo "unofficially" report significant dusting and odor problems during composting test. Magnitude of problem appears understated in these paragraphs.	Hennig	Text states "A positive means of dust control is … recommended …" No further text changes are required.
29	7	7-6	Second paragraph under Assess Product Quality……section - first sentence should read "……a moisture content of not less than 40 percent."	Bucher	Text changed
30	7	7-7	Add short discussion of flexibility which Centridry provides (dry vs. wet cake). This discussion veers away from the economics and focuses on process capabilities.	Bucher	Text added
31	7	7-7	3rd paragraph 1st sentence. Correct to note that West Point currently produces 26 to 28 percent solids (not 17 to 18 percent as suggested in this sentence.	Smyth	Text changed
32	Appendix	B	Relocate Figure B-1: Facility Operation. Currently stuck in the middle of Table B-2.	Bucher	Figure moved
33	Appendix	C-1, p3	In first paragraph, second sentence - list VAR approaches applicable to Centridry product. Similar to the list included for Class A compliance.	Bucher	Text added
34	Appendix	C-1, p3	Under section 3.2, second paragraph starts with "Two samples" - change to read two grab samples.	Bucher	Text changed
35	Appendix	C-1, p4	Under section 3.3, the issues listed which were evaluated during bin tests should be addressed clearly in results section. Simply take each bulleted issue and use for subtitle in results section. Most is covered in writeup but difficult to extract from document.	Bucher	Subsections added addressing each issue
36	Appendix	C-1, p5	Second full paragraph is in need of a source reference - expect it is the Schilp paper.	Bucher	Reference added
37	Appendix	C-1, p5	Fifth full paragraph needs to be relocated. Possible location is just after Series 2 description on page 6.	Bucher	Text relocated
38	Appendix	C-1, p5	Last full paragraph, last sentence. Insert new paragraph and spend a few sentences describing the setup of the test series detailed on the next page.	Bucher	Text added
39	Appendix	C-1, p6	Change reference to ESRP biosolids to STP biosolids	Bucher	Reference changed
40	Appendix	C-1, p6	Need short discussion of why Series 2 was largely a replicate of Series 1. Discussion included between Series 1 and Series 2 lists.	Bucher	Text added
41	Appendix	C-1, p6	After Series 2 list, add new section titled "Compost Bin Results". This section will respond to the list of issues outlined in the beginning on page 4.	Bucher	Section added. See response to Item 35.
42	Appendix	C-1, p6	Discuss Figures 1 and 2 in further detail - explain temperature dip in Figure 1 and bin 1 not meeting PFRP	Bucher	Text added
43	Appendix	C-1, p6	Second to last paragraph discussing Odor analysis. Add a few sentences describing the dilution-to-threshold measurement and related test methodology.	Bucher	Text added

No.	Section	Page	Comment	Reviewer	Response
44	Appendix	C-1, p7	Table 4 - can the difference in ammonia concentration between similar bins in Series 1 and 2 be explained? If so, add to discussion.	Bucher	Text added
45	Appendix	C-1, p8	Prior to moving on to Full-scale composting - need to discuss compost density measurements and results.	Bucher	Text added
46	Appendix	C-1, p8	Second paragraph under 3.4 Full-Scale Composting needs to be relocated to section 5.	Bucher	Paragraph moved
47	Appendix	C-1, p8	Remove last sentence in second paragraph under 3.4 Full-Scale Composting	Bucher	Text removed
48	Appendix	C-1, p9	The 4 listed LRI mixes are not supported by complete test data in Appendix C-2. King County will search for data files and forward to Consultant.	Bucher	Data provided by King County
49	Appendix	C-1, p9	In first sentence under section 3.5 Compost Testing Conclusions, remove the words "to-date".	Bucher	Text removed
50	Appendix	C-1, p9	Under Compost Testing Conclusions, need to address final compost stability.	Bucher	Text added
51	Appendix	C-1, p11	Under Economic Analysis - a 21 active composting period is defined but in Alt 2 description on page 5-12, a compost period of 18 days is defined. Which is correct - match Appendix to Section text.	Bucher	Discussion in Section 5 has been changed to 21 days.
52	Appendix	C-1	In the Legend on Figures 1, 2, and 3, add time/temperature for PFRP and VAR. PFRP = 3days at 55°C and VAR = 14 days at 40°C	Bucher	Figures modified
53	Appendix	C-2	Need to locate and add LRI trials referenced in App C-1, p9. King County will search for data files and forward to Consultant.	Bucher	Data provided by King County
54	Appendix	D	Last three sheets in appendix outline odor panel work. Dates on header of sheets should read 8/3 odor panel - day 0, 8/6 odor panel - day 3, and 8/17 odor panel - day 14.	Bucher	Dates have been changed
55	Appendix	D	List data sources: gas sample results from King County Environmental Laboratory, odor panel results from Technology Assessment Program	Bucher	Sources added to flysheet
56	Appendix	E	Add May 2000 bucket test odor results to appendix.	Bucher	Data added
57	Appendix	E	List data sources: microbiological and gas sample results from King County Environmental Laboratory	Bucher	Sources added to flysheet
58	Appendix	E	List source of microbiological data report as Technology Assessment Program	Bucher	Sources added to flysheet
59	Appendix	H	Need to include gas piping to dewatering building	Bucher	Capital cost estimates modified as requested
60	Appendix	I	List Info Sources at the end of the appendix	Bucher	Sources provided
61	Appendix	I	Sheets containing Tables 6.1, 7.1, 8.1, and 9.1 - delete header "ESRP Digester 5 Predesign"	Bucher	Header deleted